A HANDBOOK OF
ANIMAL HUSBANDRY AND DAIRYING

BY

V. T. SUBBIAH MUDALIAR

Agronomist and Professor of Agriculture (Retired)
Agricultural College, Coimbatore

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FOREWORD

This book on Animal Husbandry and Dairying has been written by the author for the benefit of the students of agriculture studying in the Universities in South India. The publication is timely in view of the great importance that is now stressed on agricultural operations, the development of agriculture and the future of agriculture and animal husbandry in the country. Conditions vary so much from country to country in regard to methods of agriculture. Such variations are brought about by climatic conditions and conditions affecting the soil and the way of life of the people. It is a matter for congratulation that the author has presented the subject in a manner that is applicable to Indian conditions and brings about prominently the methods that are utilised in India, more particularly in South India.

It is not for me to speak about the scientific aspects of the literature that is now placed before the students. But reading the book from a layman's point of view, I find that it has been written in an easy style and can be understood by the majority of people with any interest in agriculture or animal husbandry. The details given with regard to the dairying of milk and of milk products are of great value. Methods of pasteurisation and preservation of milk, standards prescribed for milk and various other important measures stressed for the supply of pure milk and its many other products are well worth perusal by the layman. The author is to be congratulated on the excellence of his work and the manner of his presentation and I trust that this will be a forerunner of other publications relating to more particular fields of agriculture and animal husbandry.

A. L. MUDALIAR,
Vice-Chancellor,
Madras University.

PREFACE

This handbook of Animal Husbandry is primarily intended for the use of agricultural students and covers the syllabus prescribed by the Universities in South India. This will also help the general reader to get an idea of the general principles governing animal husbandry and dairying and the management of farm animals.

Notes prepared by the author for class use at the Agricultural colleges at Coimbatore and Bapatla from 1929 onwards have formed the skeleton of the book. A list of the books consulted is appended as a bibliography. Since it is a text-book, it cannot by its nature make any claim to originality. The material has been drawn from several sources; the material for the section dealing with the South Indian cattle breeds for instance, has been drawn largely from *Livestock of Southern India*, by R. W. Littlewood (1937). Since the notes were prepared for class use only, references were not maintained regularly and it has not been possible to furnish the list of all the books consulted from time to time. In view of the great need felt for a book of this kind in the several colleges, the author presents the material in the hope that the readers would be indulgent and the several authors from whose works information may have been thus drawn would forgive this unavoidable lapse.

The various aspects of the subject have been co-ordinated with the requirements of the farm and the scope limited to those phases that are related to them. When the material presented induces a desire in the reader for more detailed knowledge of certain aspects, he will naturally turn to the various special treatises that are available.

Animal husbandry and dairying have been developed in Western countries, where the pressure of human population is low and extensive areas are set apart specifically for grazing. The distribution of rains also favours the growth of grass fairly well all over the year, except during winter. The number of cattle is also kept within limits, by slaughtering for beef. Under these favourable environmental conditions,

the cattle of the West have been developed through centuries, for utilising the largest quantity of high quality fodder. The Indian stock, on the other hand, have been developed on the smallest quantity of coarse fodder. The pressure of human population in India is great. Land is not available for being specifically set apart for grazing. The growth of grass is also limited to the monsoon season and land is bare at other times. Popular sentiment is against the slaughter of cattle and the pressure of cattle on land is consequently very high. Cattle live on refuse left over, after the grain is gathered for human use. These basic factors are primarily responsible for the differences seen between the cattle management practices in the West and in India. This fact influences the treatment of the material here.

This book attempts to give a co-ordinated picture of the maintenance of cattle in India and suggests certain lines of development. It forms a companion volume to the *Principles of Agronomy* by the same author, with reference to the farming conditions in South India.

The author is thankful to the Government of Madras for permitting the reproduction of the photographs of Kangayam, Ongole, Murrah and Sindhi bulls. Messrs. A. H. Subramania Sarma, A. Marie Kolandai, Lecturers at the Agricultural College, Coimbatore, and M. A. Sankara Iyer, Pulses Specialist, Coimbatore, went through the manuscript at the several stages and offered valuable suggestions for enhancing the usefulness of the book. The author's heartfelt thanks are due to them. The author is very much indebted to Professor A. Sreenivasaraghavan, Principal, V.O.C. College, Tuticorin, who found time, no doubt at great personal inconvenience, to edit the manuscript.

The author is deeply grateful to Sir A. Lakshmanaswami Mudaliar, Vice-Chancellor, Madras University, who has kindly given the Foreword.

Finally, special thanks are due to the Bangalore Press for the excellent get-up of the book.

AMBASAMUDRAM, V. T. SUBBIAH MUDALIAR.
8*th December* 1955.

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* By the courtesy of the Dy. Director of Animal Husbandry (Live-stock), Madras.

PART I

ANIMAL HUSBANDRY

CHAPTER I

CATTLE INDUSTRY IN SOUTH INDIA

Importance of cattle.—Cattle have been and are of considerable importance and utility to farmers all over the world. It is significant that they were chosen as farm animals universally even in early times, when communications had not developed and different countries were separated by vast stretches of land or sea. The people of the world could not possibly have learnt the uses and value of cattle from one another in those days. The development of cattle as farm animals took place independently in various countries. Also, it is clear that cattle were available all over the world for capture and domestication.

Cattle, and to a smaller extent horses, have been providing the chief motive power to farmers in the different countries of the world. Horses are comparatively faster, but are not useful otherwise. Cattle are different. They are an integral part of the farm and are useful in many ways. They provide the chief motive power and manure for the farm, besides producing milk, a valuable human food. They also provide beef for consumption. Tractors and machinery have supplanted horses, which were the sources of farm motive power in Western countries, but cattle have not been so replaced, nor will it ever be done.

Classification of cattle.—Cattle can be divided on the basis of their utility into three main types, as the milk, the beef and the draught types. It may be possible to combine the characteristics of all the three in a common type of animal, but only to a limited extent. There is very great scope, however, for the intensification of the individual characteristics of any one type. This has been achieved to a phenomenal extent by improved methods of breeding, feeding and management. Some world famous cows have crossed the limit of 4,000 gallons of milk per lactation. Bridge Birch, a British-Freisian cow, gave 44,289 lb. of milk in 350

days, with an average yield of 126·5 lb. of milk a day. She was giving during the peak period of production more than 150 lb. (=37·5 Madras measures) of milk a day, a quantity more than twice the weight of many new born calves. A calf requires 6 to 8 lb. of milk daily as feed and the mother cow's capacity has been raised to 20 times the feed requirements of the calf. Equally spectacular results have been achieved with the beef breeds. One year olds properly managed tip the scale at 900 to 1,000 pounds. Draught types also have been developed well. The Mysore cattle are an example. They are very good trotters and are superior to other breeds in this respect.

Though excellence of individual characters in each type has been built in cattle to extreme degrees, such a success has not been achieved in combining any two typical characters in the same animal. Milk and beef are incompatible characters and it has not been possible to combine them in the same animal beyond a certain limit. The same may also be said of beef and draught. Milk and draught power do not appear to be so incompatible. Milk recording done with the Kangayam herd of the Pattagar of Palayakottai in Coimbatore district indicates that individual cows in draught Kangayam breed are good milkers. These animals have all the characteristics of a good draught stock also. It is probable that with these selected animals as the nucleus, herds with superior, combined milk and draught qualities may be built up in course of time.

Cattle population.—The number of livestock in the Madras State including the new Andhra State, according to the 1951 census, is as follows:

Class of animals.	Cattle.	Buffaloes.
Breeding bulls	72,906	56,101
Bullocks and cows at work	7,800,067	1,144,105
Breeding cows	4,281,301	3,225,318
Cows and buffaloes not fit for work	1,225,759	376.233
Young stock under 3 years	6,036,442	3,151,475
Total	19,416,675	7,866,352
Total bovines		27,283,027

Other animals.

Sheep	15,161,169
Goats	7,424,824
Horses and mules	66,890
Donkeys	247,910
Pigs	1,022,171
Others	707
Total, other animals ..	23,923,671

The area cropped in the Madras State, including the new Andhra State, is about 32 million acres. The human population in 1951 was 57 millions and cattle population 27·3 millions, besides other classes of animals. Every 100 acres of land has to support 86 head of cattle, 75 other animals and 179 human beings. Each head of cattle has to depend on 1·16 acres and each human being on 0·56 acres of cultivable land. It is obvious that the pressure of population on land, of men, cattle and other animals is very great.

The State Fodder and Grazing Committee has estimated that the production of fodder in the Madras and Andhra States is of the following order:

Dry roughages	21,645,600 tons.
Pulse *bhusa* and green fodders	3,341,700 ,,
Pasture grasses	7,900,800 ,,
Concentrated feeds ..	1,918,000 ,,

Source: S. Y. Krishnasami, *Rural Problems in Madras*, 1947, p. 197.

If it is assumed that horses consume two-thirds, and other animals and young stock consume one-third of the quantity of fodder required by adult cattle, there would be 29,153,581 'cattle units' in all, in the two States. Each cattle unit would get 7·4 lb. of dry fodder daily on the average. Adult cattle weighing about 600 lb., require 12 to 15 lb. of dry fodder each, per day, for their maintenance. They get on the other hand 7·4 lb. only, which is much below actual requirements. The animals are therefore semi-starved, except during the rainy season and for some time after the harvest of the main crops, when there is some natural grazing in waste lands, harvested fields and field bunds.

Further, the deficit of fodder is not uniformly spread over the country. There are regions where the production is over and above the requirements of cattle, those where it is just sufficient and others where it is largely in deficit. The animals in the deficit areas are in a very poor state. Fodder production is satisfactory in rice-producing areas and straw stacks of the previous year may commonly be seen there. The fodder supply position is reflected in the size and state of the straw stacks. Fodder production is limited in rain fed areas, particularly where the rainfall is low and precarious. These are always deficit pockets which require to be supplemented with fodder from other areas and even then the deficit is not easily made up, as fodder is bulky and its transport over long distances difficult. When the rainfall is low in any year, fodder production is very much reduced and animals suffer very much. They are in a famished state and are subject to epidemic diseases. Their condition improves in years of normal rainfall. Thus cattle and other animals lead a very precarious existence. There are on the whole more animals than the land can support and the pressure of cattle and other livestock population on land is great.

Rainfall.—Cattle thrive in regions of low rainfall, where the climate is salubrious and healthy. Raising crops is not always assured there and it is a gamble with the rains. Even though the rainfall is low and insufficient for the successful growth of crops, it promotes successive flushes of grass, if it is properly distributed and raising cattle is a successful method of utilising the natural growth of grasses. South Coimbatore, North Madurai and Tiruchirapalli have a well distributed rainfall, where Kangayam cattle are bred and reared successfully. Similar conditions prevail in North Nellore and South Guntur, where the Ongole cattle are bred. The rainfall is higher here and adequate also for the growth of crops. The other regions have not got such conditions and have not developed cattle breeding to any large extent.

The crop residues and grasses in low rainfall areas are rich in minerals. The animals that are raised here attain a good size, with a strong bony build, besides being healthy. The cattle are small and puny in high rainfall regions and wet cultivation zones, as in Malabar and the deltaic areas, where the soils are leached out of nutrients. The animals are not healthy on account of the high humidity of the atmosphere and the rate of mortality is higher than in dry regions.

Soils.—Cattle thrive in soils that are rich in calcium and phosphorus, which contribute to a strong and big bony frame. The soils may be of the red loamy type as at Coimbatore or of the deep clayey type as at Guntur. It would be ideal if the rains are distributed all over the year and promote successive flushes of grass, for providing sufficient grazing for the animals.

Cattle Suitable for Different Types of Farming

(1) *Dry lands.*—The black soils are stiff and require sturdy and heavy animals for cultivation. Only big sized animals like the Ongoles and Kangayams are therefore kept in the black soil areas. The fodder produced here is of good quality and the cattle maintain their condition extremely well. Since the heavy animals are costly, they are looked after carefully and they have a longer working life, when compared to the animals in other tracts.

The red soils are of a light loamy type and do not require heavy animals for cultivation. Moisture is retained by the soil for a short time only after the rains and the various cultivation operations and sowing require to be done expeditiously, before the moisture is lost. Swift footed animals are therefore required for performing the various cultivation operations in time. Medium sized, swift footed Mysore animals are extremely suitable for this region.

(2) *Garden lands.*—Cattle power is largely used in garden lands for lifting water with *mhotes* (a kind of water lift) from wells, for a considerable part of the year. Hardy

animals that can stand the heavy strain of *mhote* work are required for the purpose. Kangayam animals are very hardy and are generally chosen for use in garden lands.

(3) *Wet lands.*—Small sized animals that would not sink in the wet mud under their weight are used for ploughing in deltaic areas. The wet land regions are humid and unhealthy for the animals and cattle mortality is higher here than in other areas. The small animals are cheap and their death is not so serious a loss as that of costly heavy animals. In the Srikakulam and Godavari districts, buffaloes are used for wet land work. They are found suitable, but they are not able to stand the mid-day sun and farmers in other regions do not fancy buffaloes for fieldwork.

Grazing conditions.—It has been seen that the pressure of human population is high in South India and land is not therefore set apart for the cultivation of fodder crops or for grazing. The existing grazing is of three types, namely communal grazing, forest grazing and private grazing.

Communal grazing.—This is grazing on land that is jointly used by the people or the community and is confined to unassigned waste lands set apart for the purpose, *porombokes*, tank bunds, harvested fields and tank beds. Unassigned lands are getting reduced in extent on account of the pressure of population on land. The grazing available in these several types of common land is insufficient for the large number of cattle in the country. There is considerable overgrazing and often the cattle get more exercise than grazing.

Young calves, cows in milk, dry cows, bullocks and old animals graze together on these common lands. The young male stock are not castrated and they mate with the cows promiscuously. The resulting progeny are weak and puny. The early mating tells on the growth of the bull calves also. They are affected permanently and grow into weaklings.

Forest grazing.—Cattle are allowed to graze in the reserved forests for a nominal annual fee and even free grazing is allowed in years of scarcity of fodder. There are three main types of forest grazing:

(1) cattle living in forests,

(2) cattle which come from distant places during the wet land cultivation season and stay in the forests for a period, and

(3) cattle coming to the forests for grazing during the day, from villages nearby.

(1) *Cattle kept in the forests.*—The important forests of this type are in Bhavani and Kollegal taluks in Coimbatore district and Hosur and Dharmapuri taluks in Salem district. They constitute the main breeding area of the Alambadi cattle. The cows are kept in the forests with their young calves and the breeding bulls. The young male stock are kept separate and are periodically sold at the several fairs held in these taluks. Only the mature breeding bulls serve the cows and the resulting progeny are therefore of a satisfactory type. Cattle are kept also in the Bhadrachalam forest area in the Godavari district. Young male stock are reared in the forests and are sold when they grow into adult cattle. There is consequently promiscuous mating and the resulting progeny are weak, puny and not as satisfactory as those raised in the Alambadi tract.

(2) *Cattle coming to the forests during the cultivation season.*—Natural grazing is not available in the deltaic areas during the rice cultivation season and cattle are also not required for farm work from the time of planting to the harvest of rice. The working bullocks and the dry cows are then sent to reserved forests, wherever available and got back at the time of harvest when the harvested fields and field bunds provide light grazing and the animals are also required for threshing rice and transporting straw.

Cattle are generally sent for grazing to forests in this way in Godavari and Guntur districts. They are left in charge of *sugalis*, a tribe of people who live in the forests. The *sugalis* are remunerated for this service. It is felt that the mortality of cattle tends to get high, when left with them. Raw cattle hide is in demand and the keepers are tempted to make easy money by sale of green hides. The system of

keeping animals in forests in charge of *sugalis* is therefore getting unpopular.

(3) *Grazing in forests by cattle from adjoining villages.*—When cheap forest grazing is available nearby, large numbers of cattle are kept in the adjoining villages and are sent to the forests for grazing during the day and got back at night. The animals are in poor condition and are of very little value. They produce some manure at a negligible cost and they are maintained primarily for the manure they produce. Such forests are in low elevations and the pasturage is of poor quality. Further, there is mixed grazing and promiscuous mating. The Cumbum valley in Madurai typifies this type of grazing. The cattle maintained on forest grazing of this kind are poor. It is, however, significant that excellent cattle are raised on arable land in the same tract.

Private grazing areas.—*Patta* lands are laid down to pasture temporarily, as well as permanently, in certain areas like the Ongole-Kandukur tract in the Guntur and Nellore districts and the Dharapuram-Palladam tract in Coimbatore district. Areas subject to washes by the side of rivers and channels in the Ongole tract are laid down to grass permanently. When sheep are folded on the land, the babul (*Acacia arabica*) seeds that are consumed by them and passed out with the dung germinate and trees get established in a natural manner in course of time. Small areas are also set apart in regular arable land and pasture grasses get established spontaneously. *Chengalli gaddi* (*Iseilema laxum*) is the prominent grass species that springs up naturally in this area. It is a nutritious grass that makes vigorous growth. The tract has a good rainfall of 30 inches distributed favourably from June to December. The soil is a deep, black, clayey type, which is well supplied with lime. All these favour the good growth of grasses.

Arable land is temporarily laid into pastures in the Kangayam tract. The land is prepared in the normal way and sown to sorghum with the south-west monsoon rains in June-July. The seeds are covered by ploughing and

kolakattai (*Cenchrus ciliaris*) grass seed is broadcasted on the surface at 25 lb. per acre, when rains are anticipated. The grass seed is not covered and it germinates satisfactorily, when the surface is moist and there is a light rain after sowing. The young *kolakattai* grass establishes, when the sorghum crop is on the land. After the harvest of sorghum, the grass makes good growth and flushes with each rain. Periodical light rains are received during the hot season, and the south-west and north-east monsoon seasons, and successive flushes of grass spring up. The land is not cultivated when it is under grass and there is thus accumulation of organic matter and nitrogen, leading to an improvement in the friability and structure of the soil. The crop in which grass is inter-sown is called the ' nurse ' crop.

Fodder cultivation.—Fodder crops are raised to a limited extent only in South India. Sorghum is sown thick in black soil areas in the Madurai, Ramanathapuram and Tirunelveli districts and the crop is made into hay. A catch crop of sunhemp is taken with the moisture in the soil, after the harvest of the rice crop in the Circars and made into hay. Fodder sorghum is sown in small patches in garden lands of the Tiruchirapalli, Coimbatore and Salem districts, during summer, for providing green feed for *mhote* bullocks. *Mhote* work is strenuous and the supply of green feeds maintains the animals in good condition.

Cattle rearing.—Young calves are purchased from adjoining districts and breeding tracts, and reared in certain areas by farmers and small peasants. Young stock are taken from the Godavari, Krishna and Guntur districts and reared in the Visakhapatnam district, for resale as adult animals. The farmers of the Ceded districts get young stock from Nellore, Guntur and Mysore and rear them for their own use. Farmers in Punganur in the Chittoor district and North Salem purchase and rear a large number of Mysore and Alambadi calves. Some calves are taken from South Coimbatore and reared in the Madurai and Tiruchirapalli districts. Coimbatore is both a breeding and rearing area.

CHAPTER II

IMPORTANT BREEDS OF CATTLE IN SOUTH INDIA

Cattle breeds.—Animals having the same set of characteristics like general appearance, features, form, size, configuration, etc., are said to form a breed. Though there may be considerable differences between individual animals, they have as a group many common points which distinguish them from other groups. The similar features are derived from the same common ancestral stock and are carried forward from generation to generation, unless altered by crossing with other types of animals. The purity of the breed is maintained by confining the mating of animals to within the breed.

The major breeds of cattle in South India are three in number, namely the Kangayam, the Ongole and the Alambadi. They are separate breeds, with their own distinctive features. Within each breed are seen large sized animals carefully bred and reared by regular breeders and the village animals of a smaller size that are not specially and carefully bred. But for the difference in size, they possess the characteristics of the breed. The breeds are found in the purest form in the centre of the respective breeding tracts. The purity of the breed tends to get lost with increase of the distance from the central breeding area, by crossing with other breeds and types of animals in the adjoining areas. Thus the coastal Circars area extending from Nellore in the south to Visakhapatnam in the north have animals broadly of the same type as the Ongole breed. There are, however, variations in type from area to area, with the main features remaining the same right through, but they cannot be classed as belonging to the typical Ongole breed. The Ongole breed proper is raised in the Ongole-Kandukur tract. Similarly, typical Kangayams are seen in the Dharapuram-Palladam tract, though almost all the cattle in the southern districts resemble the Kangayam breed, with variations of

different degrees. Thus the cattle seen in the Tirunelveli district have the same broad outlines as the Kangayam breed, but yet are so different that we cannot say they belong to the Kangayam breed, though they are of the Kangayam type.

The Kangayam breed.—This breed derives its name from the Kangayam sub-taluk of the Dharapuram taluk of the Coimbatore district. It is bred particularly in Dharapuram and Palladam taluks of the Coimbatore district. A few breeders own 500 to 1,000 head of cattle and more. Others have only 10 to 20 animals. The Kangayams are also bred in the Karur taluk of the Tiruchirapalli district and Dindigul taluk of the Madurai district, which adjoin Coimbatore. The young bull calves are reared by the breeders themselves and only grown-up adult animals are sold to dealers, who dispose off these animals at the cattle fairs held annually at Kannapuram, Tirupur, Madurai and elsewhere.

Tract characteristics.—The soils of the Kangayam breeding tract are light, red and gravelly, rather shallow, with underlying *kankar*, called locally ‘*odai jelly*’, and made up of lime mostly. The high lime content of the soil contributes to the good bony build of the cattle raised here. The annual rainfall is 20 to 25 inches, which is often uncertain in quantity and distribution, and arable farming is very precarious. The rains are distributed over a large part of the year and light rains are received during the hot weather and the south-west and north-east monsoon periods, which promote repeated flushes of grass. The light and shallow soils do not retain sufficient moisture for the satisfactory growth of crops, but enough for maintaining the growth of grasses. The predominant grass of the region is *kolakattai*, which is hardy and does not dry out during the intervening droughty periods. It puts out new flushes even after light rains.

The lands are divided into suitable blocks and fenced all round by planting *mullu kiluvai* (*Commiphora berryi*) cuttings during rainy weather. The cuttings establish easily and form an impenetrable hedge. The fencing of land is

a special feature of this tract, seldom seen elsewhere. Big paddocks are provided with wells that have one side sloping for cattle to get in for drinking water. Cattle are kept in these fenced pastures without any protection from the sun and the rain, excepting for the light shade provided by the white babul (*Acacia leucophlœa*) trees growing here and there. Small peasants and breeders provide light wind-breaks to serve as shelter during the south-west monsoon season. They are made up of cotton stalks plaited together and held in position by vertical stakes driven into the ground. The animals are not protected against the weather otherwise and they develop a hardiness, endurance and strength, rarely seen in other breeds.

Big breeders group their stock into herds of different ages and sex, and keep them in separate paddocks. Selected breeding bulls are let into the paddocks along with the breeding cows and heifers, and thus breeding is controlled. Breeding bulls from other herds are sometimes used for avoiding close-breeding. The small peasants have their cows served by the bulls maintained by the big breeders. The service is usually free, with the bull owner retaining the option to purchase the male progeny. Young bulls are used for such service. The breeder is thus enabled to test the capacity of his bulls to impress their characters on the progeny. The District Boards and certain co-operative institutions maintain selected breeding bulls approved by the Animal Husbandry Department and arrange for the service of cows in villages for a nominal fee. The State also grants premia to individuals and societies that maintain approved breeding bulls for serving village cows and charge only reasonable service fees. About 1,200 breeding bulls are maintained in the Madras and Andhra States under the premium scheme. The small owners are thereby enabled to secure the services of suitable breeding bulls and the animals so raised are nearly as good as those raised by the big breeders. The premium scheme is therefore of special value in areas, where the small peasants rear their calves carefully, as in the regular breeding and rearing areas.

Rearing calves.—The young calves depend upon milk up to six weeks, when they begin to nibble grass. They are then turned to pastures and the milk allowed to them from their dams is gradually reduced. They are also given some gruel made with cereal grains and rice bran from the sixth week onward. Weaned calves subsist solely on pastures after they are about six months old. They are given some straw, sorghum, *cumbu*, or rice, when there is extreme drought and the pastures are completely devoid of grass. The bulls are castrated when they cut their second pair of permanent teeth at 3½ years and are trained in light work, like ploughing and carting. They attain full growth in five years and are then used for heavy work like lifting water from wells.

The Kangayam bullocks are good working animals. The black cotton soil farmers of Tirunelveli and Madurai prefer them to other types of animals and the peasants of the Kangayam home tract sell the animals raised by them and carry on their cultivation with the cheaper Alambadi animals. The Kangayam animals are sturdy, well built, muscular and medium sized. They have a long working life of 10 to 12 years at the *mhote*, while the Mysore and Alambadi animals break down after 5 to 7 years of heavy work. The Kangayam animals are very thrifty and get on even with scanty rations. They do not lose condition easily, even when they are put to heavy work. They pick up lost condition quickly with a little rest and proper feeding for a short time. All these favourable traits appeal to the peasants, who prefer them to other breeds, particularly for hard and strenuous work.

The Kangayam cows are poor milkers in general. They calve once in 15 months with the big breeders and once in two years with small peasants. Cows which do not conceive readily are used for fieldwork and if they fail to breed even then, they are sold as work animals. The use of cows as work animals is a feature of this tract. The cows are good draught animals for their small size and are an economic source of power for the small peasants.

The Pattagar's herd.—The Pattagar of Palayakottai in the Coimbatore district raises a large Kangayam herd and is the biggest cattle breeder in India. He has extensive pasture lands and over 1,500 to 2,000 head of breeding stock, and sells 300 to 350 breeding bulls annually.

The pastures at Palayakottai are divided into paddocks of 50 to 200 acres each and fenced with *mullu kiluvai.* The animals are separated into herds of milk cows, dry cows, heifers, young calves, etc., and left into different paddocks. Selected breeding bulls are let in with the breeding cows and heifers. Big paddocks have wells for providing drinking water.

The Pattagar's animals are raised on pastures mainly, though grazing is supplemented with straw, when necessary. The milk cows, sick animals, young calves and breeding bulls are given some concentrated feed. The other animals subsist solely on grass. Bullocks intended for sale are given some concentrates, including some *Acacia* pods, when available, a little before they are taken to the market. Feeding with white babul pods gives a bloom and a sleek and polished coat to the animals, which enhance their sale value.

The milk yields of Pattagar's herd are being recorded by trained personnel for some years now, under a scheme financed by the Indian Council of Agricultural Research, New Delhi. Some potential milkers have been located in the herd and these cows are to be used as a nucleus for building up a milk strain in the Kangayam breed. Systematic breeding of animals and building up milk qualities have not been seriously taken up so far in the country and the evolution of milk breeds is a real need.

Breed characteristics.—The following are the important characteristics of the Kangayam breed:

The Head is short, forehead level, eyes dark, ears short and horns diverge and incline backwards.

The Neck is short, thick and muscular.

The Hump is fairly well developed.

The Dewlap is thin and extends up to the sternum.

FIG. 1. A Kangayam Bull

By the courtesy of the Dy. Director of Animal Husbandry (Livestock), Madras

FIG. 2. An Ongole Bull

By the courtesy of the Dy. Director of Animal Husbandry (Livestock), Madras

The Body is compact and well ribbed up.

The Back is short, broad and level.

The Quarters are well formed, strong and lightly drooping.

The Sheath is tight and closely adhering to the body.

The Tail is moderately long and thin.

The Legs are short and thick boned.

The Feet are small, black and hard.

Colour.—The bulls are grey and considerably darkened about the head, neck, hump and hind quarters. The cows and bullocks are more or less white. The young calves are red in colour at birth and change to grey in about six months.

Hair and Hide.—The hair is fine and soft. The skin is black.

The cows have black rings round the eyes and they are poor milkers in general.

The Ongole breed.—The Ongole cattle are a distinct type of heavy animals seen from Nellore in the south to Visakhapatnam in the north, though there are considerable variations of the main type from place to place. The best animals true to the breed are seen in the arid taluks of the Guntur district and Kandukur and Darsi taluks of the Nellore district. This region forms the centre of the tract, where the animals may be taken to be typical specimens of the breed. The Ongole animals are heavy draught animals, which are rather slow at work. They are generally white or light grey in colour. There are also animals which are predominantly red or black, with white patches, which are said to be the Devarshola sub-breed of the Ongole type. Animals in the central Ongole tract have light shaded spottings over the body, that give an oily appearance and an apparent translucency over the spots. The horn characters are not well defined; no two animals have like horns. The horns are short and bent in different directions. Some animals have stumpy horns, which make but little growth. They may also be cracked on the surface and sometimes loose and shaky. The loose horns of some young animals get fixed later.

The central breeding area of the Ongoles is in the heavy black soil region. The soil is rich in lime and contributes to the good bony build of the animals. The rainfall during the south-west and north-east monsoon periods from June to December of about 30 inches is favourably distributed. The soil retains moisture fairly well and this contributes to the satisfactory growth of grasses and the tract is not precarious like the Kangayam tract. The Guntur black soil area is also extremely favourable for the production of crops. The soil is deep and fertile. Commercial crops like chilli, tobacco and groundnut are grown without irrigation. It is interesting to study how the cattle industry developed in a region so favourably placed for the production of crops. The density of population was low originally and there were no market and transport facilities for the disposal of surplus agricultural produce. There was also the scare of invaders and marauders from the north, and the intolerable demands of petty officials, which might have induced the people to choose the more mobile cattle as their wealth, that could be transported easily at the slightest alarm. The black soils are stiff and require good draught animals for ploughing and other cultivation operations, and the peasants have to maintain their work animals more carefully than in other places. This developed in the farmers a love for cattle. The black soil farmer is justly proud that he understands cattle and rears them better than others.

The breeding of Ongole cattle is being neglected now and more attention is being devoted to the cultivation of commercial crops in the Guntur district, as being more remunerative. The area devoted to the cereal and fodder crops has been considerably reduced, with consequent reduction in the quantity of fodder produced; but more animals are kept than is warranted by the fodder produced. The animals that are raised are not therefore of the same high quality as before. Bullocks required for work and bull calves that have a potential market are fed properly. Cows and heifer calves are given the fodder

left over by work animals, with which they have to get along.

There are not any big cattle breeders of repute here as in the Kangayam tract. Small breeders keep 10 to 15 animals in the Ongole tract, while some breeders in Kandukur area maintain 50 to 100 animals. Some breeders keep up to 500 head of cattle in the deltaic areas of the Nellore district. This is an instance, rather rare, of deltaic farmers taking an interest in cattle breeding.

When rich people die, their heirs dedicate bull calves in memory of the deceased, to serve as breeding bulls for the community, called '*brahmini*' bulls. The name 'brahman' given in North America to zebu cattle is derived from the term *brahmini*. Very good animals were selected as *brahmini* bulls in the past by committees of village elders and were dedicated. They roamed about, fed on the standing crops and served as the village breeding bulls. All these have changed. Poor and worthless bull calves are dedicated by people to salve their conscience and satisfy the religious scruples of the other members of the family. The bulls are not allowed to graze freely everywhere as before, nor are they looked after properly and so, they are generally in a poor condition. Big breeders maintain breeding bulls, which are allowed to serve the village cows also, but this is not a regular feature. The total number of breeding bulls in the tract is limited and immature bull calves are also requisitioned for mating. This is not good for the bull calves and the progeny they beget are weak and poor. This is one reason for the deterioration in the general standard of Ongole cattle, besides the changes in cropping and the consequent reduced production of fodder already referred to and the export of good milch cows to cities, for supplying milk.

The dry cows and working bullocks have no grazing facilities in deltaic areas after the planting of rice. They are then sent to forest areas for grazing and got back at the time of the harvest of the rice crop, in December-January. Grazing is available in the harvested rice fields till March.

The animals are stall fed with rice straw till July, when they are sent to the forests again. There is considerable mixed grazing in the forests, accompanied by promiscuous mating, often with other types and breeds of bulls. The animals maintained in the wet deltaic areas are not therefore so satisfactory and true to type as those maintained in the dry regions. The latter are kept in the farm itself, in temporary pastures and field bunds which provide some grazing. This is supplemented with cereal straws and leguminous residues collected from the threshing floor and stored for use as fodder. The mating of the animals also is under control. There are not any bulls of other breeds in these areas and the cows are served by the bulls in the villages, which are all of the Ongole breed. The purity of the breed is thus maintained.

Bull calves are carefully reared from birth. They are allowed all the milk their dams secrete and which is not hand-drawn. They are fed with concentrated feed later and they grow into fine animals. Thirty to forty per cent. of the weaned bull calves are exported to Visakhapatnam, Cuddapah and Kurnool districts for rearing. The heifer calves are neglected and they are not allowed to have full feed of milk from their dams, particularly in urban areas, where milk has a ready market. They are not given any concentrated feed and they have to get along with the natural grazing and the straw that may be available. The heifers make slow growth and conceive when they are three or four years old. Even after calving, they are not adequately fed and future calvings are also irregular. They are valued only as mothers of prospective bull calves.

There are a class of professional rearers of cows in the Ongole tract, called '*mallas*' who specialise in rearing heifer calves. They purchase selected heifer calves, rear and sell them after they calve, for meeting the steady demand for cows, from outside the breeding tract. They are taken to Madras, Hyderabad and Visakhapatnam, for meeting the great demand for milk. The best of the milk stock are taken away from the breeding area and the poorer animals

are left behind for maintaining the breed. This results in a slow and steady fall in the standard of the breed. This is just the reverse of what is being done with regard to the improvement of milk breeds in Europe and America, where the best of the animals are retained for breeding and the poor animals are fattened off for beef, thus preventing them from breeding and producing poor progeny.

The fate of the milch animals exported to Madras is a sad story. Madras imports about 3,000 animals annually from the Ongole tract. The railways provide facilities for the return of the dry cows to the home tract, at concessional rates, but only a few animals are sent back. The *mallas* maintain the dry cows and return them to Madras after calving. The number of animals that are so maintained during the dry period is limited and many animals are sold for beef. The calves are neglected by the Madras milkmen. They are allowed very little milk and are slowly starved to death, which is considered more economical than rearing. The price of fodder is high in Madras, and calves are therefore treated as a great liability.

The Ongole cattle thrive extremely well in the black soil areas and the best specimens can be seen only here. The forage and fodder produced are rich in lime and contribute to the big bony build of the animals. All the pulse *bhusa* and husk are carefully collected and kept stacked for feeding cattle. The animals bred and reared in the red soil areas of the Palnad and the Nallamalais do not attain the same standard as those raised in the black soil areas. The cattle raised in the deltaic areas are mostly stall fed and rice straw is the chief feed. The calves do not get any exercise and develop into clumsy animals, which are slow at work.

The Ongole breed provides excellent stock and it has been introduced into many countries like Brazil, Puerto Rico, Trinidad, etc., for improving the local *indicus* and *taurus* stocks. The Ongoles have been found to be extremely suitable for crossing with the stock in those countries and

improving them with regard to the ability to resist diseases and to withstand the great heat of the summer and in certain instances to improve the constitution.

Breed characteristics.—The following are the important characteristics of the Ongole breed:

The head.—The face is moderately long, forehead is broad and ears fairly long and drooping. Horns are short and stumpy, with looseness in certain cases. Horns also tend to get cracked with age.

The neck is short, thick and muscular, and surmounted by a well developed hump, sometimes inclined to a side.

The dewlap is thick and fleshy. It hangs in folds and extends up to the navel.

The body is massive, long with well arched ribs, and a deep, wide chest.

The back is moderately long, broad and high near the croup.

The hind quarters are strong with a gentle droop behind.

The sheath is fairly pendulous.

The tail is thick at base, short and extends a little below the hock.

The legs are strong, massive, fairly long and set square.

The feet are large and rather soft.

The colour is white or grey, with dark shades about the hump, neck, quarters, knees and fetlock in bulls.

The hair and hide.—The hair is fine and smooth, and the hide is rather thick.

The cows are good milkers in general.

The Mysore cattle.—The Madras and Andhra States take in annually about 60,000 head of working cattle from Mysore. They are in common use in the red soil tracts of the southern districts and Anantapur and Bellary districts, for agricultural work. Some animals are used for road work also, though the development of motor transport in recent years has reduced the importance of these animals for this.

Mysore has some good breeds of cattle, which are of a distinct type. It is believed that the nucleus stock was originally brought to Mysore from North India by the wandering tribes of people, called ' Hallikars ', who settled down finally in Mysore. The breed was developed by the fostering care of the rulers of Mysore. The bullocks were largely used for military purposes in the earlier years, when motor transport had not developed. Chikka Devaraya Odayar, one of the Mysore rulers, established a separate department for the breeding and management of cows, called *Benne chavadi*. Hyder Ali, a later ruler, recognised the value of these animals for military purposes and called the department looking after them *Amrit Mahal* (Milk-House). The herds were neglected after the defeat of Tippu Sultan, son of Hyder Ali, at Seringapatam. The breeding of these animals had a chequered career for a time, being managed by the Mysore Government and the British Military authorities at Bangalore, with changes in control and management. Finally it was handed over to the Mysore Government in 1883.

Three sub-varieties of the Mysore breed of cattle are recognised, namely *Hallikars*, *Hagalavadi* and *Chittaldrug*. Their general characteristics are more or less the same, with minor differences caused by changes in local environment. It is believed that the three sub-breeds lost their originality and got considerably mixed up, when the herds of Tippu Sultan were disbanded after his fall. The sub-breeds were re-formed later. They constitute the Mysore breed.

The extensive forest areas in Mysore tableland are divided into grazing grounds or *kavals* and each herd is allotted 3 to 9 *kavals*, depending upon their capacity to carry grass. Each herd consists of 100 cows, 100 heifers and 5 bulls. The grounds are classified into hot, wet and cold weather *kavals* and the animals are sent to those appropriate to the season. At the time of taking stock each year, poor animals and those that have broken colours are removed from the herd and sold. Unmarked

animals are branded. The animals are kept under natural conditions and the only protection they have is what is provided by the forest trees. They roam about freely and develop a wild and unruly temper and have to be broken for work carefully. Under the rigorous climatic conditions that prevail and a changing environment, there is a kind of natural selection and the weaklings perish.

The young calves are left with their dams during the day and are sheltered at night. They start feeding on grass in about two months and live largely on it after three months. They are completely weaned at five months and kept in rich pastures, without any supplementary feed. The bull calves are castrated when they are 18 months old. The bullocks are in full vigour at five years and gradually decline after 12 years. The heifers calve when they are five years old and subsequent calvings are irregular, once in $1\frac{1}{2}$ to 3 years.

Breed characteristics.—The following are the important characteristics of the Mysore breed of cattle.

The head is moderately long, with a bulged forehead. The ears are long, and the horns are erect and long with a backward graceful sweep.

The neck is thin and wiry, surmounted by a big hump.

The dewlap is thin and small, and extends up to the sternum.

The body is deep and compact with well sprung ribs.

The back is fairly long and rises lightly near the croup.

The hind quarters are narrow and slope from the croup to the tail.

The sheath is tight and adheres to the body closely.

The tail is long and tapering.

The legs are of moderate length, strong and thin.

The feet are small, hard and black.

The colour is iron grey or grey.

Hair and hide.—The hair is fine and the skin is dark.

The cows are poor milkers. The bullocks are well formed, graceful, fast and swift at work, wiry and spirited.

The Alambadi breed.—This breed derives its name from the village Alambadi in Bhavani taluk of the Coimbatore district, where the animals are assembled for sale. The breed goes by different names like *lambadi*, *malai madu*, *Salems*, *mahadeswarabatta* and *Cauvery* breed. The breeding of the animals is confined to parts of Bhavani, Kollegal, Hosur and Dharmapuri taluks and the adjoining Mysore territory. The cattle are kept mostly in forest grazing areas. The cows alone are kept in the villages at the time of the annual harvest, when there is sufficient grazing in the fields and also when the calves are young.

The young male calves are weaned and sold before they are a year old. They are taken to Coimbatore, Chittoor and the West Coast for rearing. There are not any grown-up male calves in the grazing areas and promiscuous mating is absent. Breeding bulls are kept in the forests, along with the cows.

The Alambadi animals are fairly good working animals. They resemble the Mysore breed to an extent, but do not come up to the same standard. There are two distinct types of Alambadi cattle, one with a compact build like the Mysores and the other rather loosely built, with possibly some dash of Ongole blood. The latter are slow at work and are not preferred by farmers. The loose framed cows have a fold of skin forming the navel flap, as in Ongole cows. The cows are commonly used for farm work in the tract, as the bull calves are sold off at an early stage and the stock of bullocks is limited.

Barghur hill cattle.—These animals are bred in the Barghur hills in the Bhavani taluk of the Coimbatore district. They resemble the Mysore cattle and are probably a cross between the Mysores and the local mixed stock. They are very fiery and spirited, with considerable endurance and speed. The cows are poor milkers. Both the cows and bulls are multicoloured and spotted. The Barghur cattle form a minor breed of local importance.

Pullikulam or Jellicut breed.—This is the breed that is largely seen in South Madurai, especially in the Cumbum

valley and Periakulam taluk. There are fairly good grazing facilities in the low elevation forests in this area, though the grasses are of a poor type. But the *jellicut* animals are raised on arable land. They resemble the Kangayams in a general way and are smaller in size. They are hardy and trot well. A large number of bulls are reared for *jellicut* or bull baiting, which is a favourite pastime in this region. The animals intended for *jellicut* are handled from birth, solely by the owner. No one else is allowed to handle them and so, they resent the presence of strangers and are easily excited by them. At the time of the *jellicut* festival, coloured clothes are tied round the horns of bulls, together with jewelry and cash and they are released one by one along a narrow gangway, formed by two rows of open bullock carts. The bulls are excited by the crowd and the beating of drums. Trained people attempt to catch the bulls and secure the jewelry, and this is resented and resisted by the bulls. People attempting to catch them are sometimes injured severely, but the sport continues to be popular even to-day and people throng in large numbers to witness it or to participate in catching the bulls. Good fighting bulls that are not caught in any of these festivals are highly valued and the value rises with the number of *jellicuts*, from which they return without being caught.

The Tanjore polled cattle.—The bullocks in Tanjore district have no horns and look very different from the other cattle in South India. This polled character is not inherited, as it is with some of the polled breeds in the West. Young bull calves are dehorned by applying red hot iron to the horn buttons. The ears of the calves are also cut short and shaped to a point. It is said that dehorning makes the bullocks strong and docile. Dehorning improves the herd behaviour of cows and bulls in the Western countries and facilitates economy in the housing of cattle. Dehorning with red hot irons is painful and touching the tender horn buttons with caustic soda pencil is preferable. This has to be done when the calf is about a week old and the horn

button is soft and tender. The hairs round the buttons are clipped and the surrounding skin is protected by smearing vaseline. The horn button is slightly moistened and rubbed with caustic soda pencil, till the entire surface is raw. This destroys the horn button and prevents the growth of horns.

The Tanjore cattle are only indigenous stock and resemble the Kangayams in a general way and are smaller in size.

Buffaloes.—Buffaloes are related to cattle and go by the name of *Bos bubalis*. They are good dairy animals and produce more milk and butter than cows in India and they are valued as producers of ghee. They are also in an undeveloped state like cows. Even so, selected buffaloes compare favourably with the improved dairy cows of Europe, as far as butter production is concerned. They are hardy animals that make an efficient use of fodder rejected by other classes of stock. They are not fastidious in their feed habits and are economic animals for the small producers. Poor people maintain one or two buffaloes and eke out their livelihood by selling the milk produced. Large numbers of buffaloes are kept in Coimbatore and Guntur districts. They are centres of ghee trade and export large quantities of ghee regularly to Madras and to some North Indian towns.

Buffalo bullocks are not commonly used for farm work, except in certain deltaic areas. They are slow at work and do not stand the mid-day sun. Where speed is not important and the work is of a heavy nature, they are preferred to bullocks, as with carting stone and timber in hilly country, and working sugarcane crushers. South Ganjam, North Visakhapatnam, Guntur, Krishna and West Coast districts use buffaloes commonly for farm and road work.

With cattle, the bull calf is properly looked after and the heifer calf is neglected, as bullocks are more valuable than cows. It is the reverse with buffaloes. The heifer calves are looked after carefully and the bull calves are neglected, as the she-buffalo is more valuable than the buffalo bullock. Buffalo milk is very rich and even light over-feeding induces

scour in young calves. The incidence of worms in the intestines and stomach disorders are also very common. They, however, get hardy later, after about six months.

The buffaloes are black in colour and have a glossy coat, with only a few hairs. Some have a pale red creamy skin either on the underside or over the whole body in varying proportions. The hairs springing from the light skin are grey or white in colour, while those springing from the black skin are black in colour.

The buffaloes in South India are of non-descript types and are more or less alike in general appearance. They are small compact animals. Those in Ganjam and Visakhapatnam districts are bigger in size and are a distinct type, called the Parlakimidi or the Kimidi type. They are good milkers giving about 8 lb. of milk a day on the average, with the best specimens giving up to 20 lb. The toda buffaloes of the Nilgiris are a distinct semi-wild type and yield fair quantities of milk. South Kanara buffaloes are of a fierce disposition and the bullocks are often used for competitive racing in swamp rice fields.

FIG. 3. A Mysore Bull (Hallikar)

By the courtesy of the Dy. Director of Animal Husbandry (Livestock), Madras

FIG. 4. A Murrah Buffalo Bull

By the courtesy of the Dy. Director of Animal Husbandry (Livestock), Madras

FIG. 5. A Sindhi Bull

By the courtesy of the Dy. Director of Animal Husbandry (Livestock), Madras

CHAPTER III

OTHER IMPORTANT BREEDS OF CATTLE

The Murrah or Delhi buffalo.—This is a native of South Punjab and Delhi States and is now found distributed in various parts of India. The bullocks are not suitable for draught like the local buffaloes, as they do not stand the mid-day sun. The Murrah buffalo cows are efficient milk and ghee-producing animals and are maintained in almost all Indian cities for production of milk. They are also used for improving the capacity of local buffaloes, by crossing. Cross bred buffaloes with varying proportions of Murrah blood are found round about Guntur and to a smaller extent near Coimbatore and Vijayawada. The livestock research station, Lam, at Guntur has a nucleus herd of Murrah buffaloes. Many veterinary hospitals and agricultural stations maintain Murrah buffalo bulls, for serving local buffaloes.

The Murrah buffaloes are massive with a stout and capacious barrel. The legs are short, and the neck and head are light when compared to the body. The buffaloes are black in colour, though light patches with white hairs about the legs and head may be met with. The udder is big and capacious and the best specimens give up to 10,000 lb. of milk per lactation, with 7·5 to 8·5 per cent of fat. Selected Murrah animals, even in the present undeveloped state, can compete with the improved dairy breeds of European cattle with regard to the production of butter.

The red Sindhi breed.—This is a native of the western parts of Sind and the Las Bela area of Baluchistan. It is considered to be the most economical and the best of the milk breeds of cattle in India, with an average lactation yield of 3,800 lb. of milk in herds that are maintained properly. The best animals give up to 12,000 lb. of milk in a little over 300 days. They are capable of adapting themselves to varying soil and climatic conditions and are fairly resistant to the more common diseases prevalent in India.

The Sindhi bullock is a medium sized animal, that is capable of doing heavy work, both in the field and on the road, though slow. It is used for cross-breeding with the various local breeds throughout India and improving the milk yield. A number of Sindhi animals have been exported to Korea, Brazil and Cuba, where pure Sindhi herds are being maintained, to serve as nucleus stock.

The Sindhi animal is commonly of a reddish dun colour, though lighter and darker shades may often be met with. The bulls are a little darker than the cows. A few animals have white spots and patches about the hump, the dewlap and the abdominal region. The animals are medium sized; an average cow weighs 750 lb. and an average bull 925 lb.

The Sindhi cow is popular as a good milk animal. There used to be a regular movement of Sindhi animals from Karachi to Madras, before the partition of India, in 1947. Considerable restrictions have since been imposed on the export of these animals from Karachi and other places in Pakistan.

The various veterinary hospitals and agricultural stations in the Madras State are maintaining Sindhi breeding bulls, for serving the local cows. The livestock research station at Hosur maintains a Sindhi herd of about 450 animals, for the development of the breed. The average milk yield of the Hosur herd was 12·5 lb. a day during 1949–50. Thirty-six per cent. of the animals gave less than 3,000 lb. of milk during the year, 46 per cent. from 3,000 to 5,000 lb., and 10 per cent. from 5,000 to 7,000 lb. The highest yield was 10,738 lb. in 318 days, with a daily average of 33·8 lb. of milk.

Breed characteristics.—The following are the important characteristics of the Sindhi animals:

The head is short with a broad forehead. The muzzle is broad, ears are long and drooping, and the horns are short and thick.

The neck is short, fairly thick and well developed.

The hump is big and well developed.

The dewlap is generous, fleshy and hangs in nice folds, extending up to the sheath.

The body is short and compact, with a broad chest.

The back is short and raised near the croup.

The hind quarters are narrow and drooping.

The tail is long and tapering.

The legs are short and strong.

The feet are fairly large.

The colour is red dun.

Hair and hide.—The hair is fine and the skin is dark.

The cows are the best milkers in India. The udder is big and capacious, with a tendency to be pendulous, particularly with old animals. The fold of the navel skin is very pronounced.

European breeds.—The humpless cattle of Europe and the humped Indian animals belong to the same genus '*Bos*' and to the species '*taurus*' and '*indicus*' respectively. Animals of different species do not cross readily and even when they cross, the resulting progeny, called 'hybrids', are generally infertile. The European and Indian breeds of cattle, however, cross readily and the resulting progeny—both the bulls and the cows—are fertile; they cross among themselves readily or with either parent.

The European and Indian breeds of cattle have been developed on opposite lines, which render them very suitable for the respective environment under which they are brought up and for the purpose for which they are developed, but not under other conditions. Their inherent opposing characteristics are the following:

(1) The *taurus* animals make the most efficient use of the largest quantity of feed and the *indicus* animals make the most efficient use of the smallest quantity of rough fodder. The latter have a hardy digestive system and are able to extract nutrition even from the coarsest fodder.

(2) The *indicus* animals have a better heat regulating mechanism, with a larger dark coloured skin surface and perspiration glands. The temperature of the body does

not therefore rise up in hot or warm weather, as with *taurus* animals, which pant heavily and do not function efficiently in a hot climate.

(3) The *indicus* animals have a tough skin and a repellent sebum, secreted by the sebacious glands and are not therefore affected by ticks and other parasites to the same extent as the *taurus* animals.

(4) The *indicus* animals have a high resistance to infectious and epidemic diseases. Even when they are affected by diseases, the attack is mild compared to that in the *taurus* animals. The common foot and mouth disease is generally fatal to the *taurus* animals, while it affects the *indicus* stock only mildly and weak animals alone succumb to it. It is so with regard to other epidemic diseases also.

(5) The *indicus* animals have a poor milking capacity when compared to the *taurus* animals.

The *taurus* dairy cow has been evolved specially for high milk production. The bulls have been used for crossing the local cows in various parts of the world, with the object of improving the milk capacity of the progeny. Crossing trials in Madras have been mainly with the Ayreshires imported from England. The first generation hybrids were a considerable improvement over the local stock. They were vigorous, in common with hybrids in general. They were able to withstand the high temperature prevailing here to an extent, though not so well as the local stock. They required, however, good feeding for the maintenance of their condition. When the hybrid cows were mated to *taurus* bulls and their blood in the second generation raised to 75 per cent., the animals were not able to cope with the tropical conditions. Consequently, the *taurus* blood was attempted to be maintained at the 50 per cent. level by mating the half-bred animals. Even so, the animals weakened from the third generation onwards. Also, they were not able to yield as much milk as the first generation. Further, the hybrid animals developed weakness of the hock, after a few generations. In view of these disabilities, the cross-bred animals were back

crossed to the Indian animals to improve their constitution and vigour. This resulted in lowered milk production. Loss of either vigour or capacity for producing milk appeared to be inevitable with the cross-bred stock and nothing was gained by crossing the *indicus* and *taurus* stocks.

The hybrid bulls are without humps like their *taurus* parents. This is a disadvantage, where the male stock are used for draught, for the yoke has to rest between the hump and the horns. Also, the bullocks are not able to stand the sun.

The hybrid calves are subject to stomach disorders, ring worm and mange, and early mortality is high. The calves lack vigour, particularly when young, though they grow satisfactorily a little later and make up for lost growth.

Hybrid stock are more susceptible to epidemic diseases than local cattle and mortality among them is higher. Even when the cross-bred animals recover, they take a long time to regain their normal condition.

Though cross-breeding with the European cattle has not been much of a success here, it has not been uniformly so in other countries. Wood[25] indicates that in Trinidad, Canadian-Freisian cattle crossed on to zebu, originally imported from India, has produced excellent stock and that the *taurus* blood has been steadily increased to seven-eighths, without loss of constitution. Jersey and Red Poll have been successfully used in Jamaica to improve the dairy quality of the local zebus. Guernseys have been a success in Puerto Rico in grading up local cattle. Hawaii has built her dairy industry successfully by crossing local cows with Guernsey and Jersey bulls. All these indicate that in South India, the choice of Ayreshires for crossing the local stock may have been unfortunate. Freisians, Jerseys, Red Polls and Channel Island breeds may perhaps be more suitable; they have done well in crosses with local zebus in other countries and it is not improbable that one or the other may do well here also.

Some *taurus* bulls were introduced by the coffee and tea planters in the Anamalai plantations in Coimbatore district,

for crossing the local cattle for improving the milk supply in their estates. It is not known what breeds were introduced by them originally. Some of the cross-bred cows that have been brought to the plains appear to have Jersey blood. They do well in the plains, where the temperature is high, indicating that the trial of other European breeds for crossing may give different and better results. It must also be emphasised that the evolution of better milking animals must be combined with better feeding.

It is interesting that while India attempted to improve the local cows by importing and crossing with European breeds, the Indian cattle, called the 'zebu' in other countries, have been imported and used successfully for improving the local cattle in Java, Philippines, Brazil, Puerto Rico and Trinidad, by crossing. In the warmer sections of the United States of America, the zebu thrives and puts on weight on poor pastures, which practically starve the *taurus* animals. The zebus are in demand in regions that have rough and poor pasturage. It is said to improve the constitution of the *taurus* stock in Texas and thus to aid in increasing the productivity of stock there. The inherent capacity for high milk production that the *taurus* animals may have does not exhibit itself under the trying conditions in Texas. When their constitution is improved by crossing with the zebu stock, the capacity inherent in the *taurus* blood shows itself and milk and meat production are increased.

Cattle of All-India importance.—The great value of registering cattle of different breeds in improving stock has been generally recognised. To secure uniformity in the methods of registering animals and the maintenance of herd books, the International Institute of Agriculture at Rome set up an International Convention in 1936. It recommended that there should ordinarily be one herd book only for each breed in any country, as the maintenance of different books by the various units constituting the country would lead to considerable confusion. The Indian Council of Agricultural Research recognised the value of the suggestions and

implemented them. Certain breeds of cattle are distributed in many States of the Indian Union. Eight breeds of cattle have been declared to be of All-India importance and their herd books are to be maintained by the Centre and not by the constituent States. These breeds are: (1) the Murrah buffaloes, (2) the Sindhis, (3) the Ongoles, (4) the Tharparkars, (5) the Girs, (6) the Kankrej, (7) the Harianas, and (8) the Sahiwals. Definition of the characteristics of these breeds that would serve as the basis for the classification of the different breeds are furnished in *Miscellaneous Bulletin* No. 27 (1939), issued by the Indian Council of Agricultural Research, New Delhi. A brief description of the last five breeds is given below; the first three have already been dealt with.

(1) *Tharparkar.*—These cattle are native to south-west Sind and are now raised in the adjoining districts as well. Their capacity for milk production is high and they are able to thrive on scanty supplies of poor fodder. It is one of the best milk breeds in India.

The Tharparkars are medium sized compact animals, with clean limbs and good feet. The face is long, the forehead is lightly bulging and the poll is fairly wide. The hump is pronounced and the dewlap and sheath are moderate in size. The navel skin forms a light fold in cows. The udder is of moderate size and well held up, instead of being baggy and pendulous as in the Sindhis.

(2) *The Gir breed.*—The Gir cattle have their native home in the forests of Kathiawar and are now found in Western Rajputana, Baroda and Bombay. The cows are good milkers and the bullocks are strong and powerful draught animals, rather slow at work. The ears are big, long and drooping. The forehead is broad and overhanging over the eyes, giving a drowsy look to the animals. The horns start from the sides of the poll and grow back, up and outwards, which tend to give an impression of accentuated width to the naturally wide forehead. Pure colours are not generally met with and various forms of mottling on a white

or grey background are common. The dewlap is of medium size and the sheath is large and pendulous. The navel in cows is a big flap of hanging skin. The tail is long and whip-like.

(3) *The Kankrej breed.*—This is one of the best draught breeds of India. The bullocks are fast, powerful draught animals. The cows are good milkers. This breed was exported to America and other foreign countries in the past for grading up the indigenous *taurus* stock kept there under tropical conditions.

The home of the Kankrej breed is the south-west corner of the Tharparkar district in Sind and Ahmedabad in Bombay State. The animals have an erect carriage with large fore-quarters and a broad chest. The hump is well developed and the dewlap moderate in size. The body is moderately long. The head is comparatively short and small in size with a broad forehead. The horns are thick and grow upward and outward near the base and turn inward near the tips.

(4) *The Hariana breed.*—This is bred in Punjab and Delhi States and taken to various cities in North India for meeting the milk supply. The cows are fairly good milkers. The bullocks are good work animals used for fast road work and various farm operations.

The breed has a long face and flat forehead. The horns are short and curve upwards from the outer edges of the poll. The body is moderately long, the hump, dewlap and sheath are small, the udder is well formed and the legs are muscular and provided with good feet.

(5) *The Sahiwal or Montgomery breed.*—The Sahiwals have their native home in Central and Southern Punjab. They are good milkers and are taken to various cities for meeting the milk supply. The bullocks are sturdy draught animals, rather slow at work.

They are stocky animals with short legs. The head is short and the forehead is wide. The horns are short and stumpy. The hump is massive, dewlap and sheath are generous and hanging and the udder is capacious and pendulous.

CHAPTER IV

BREEDING PRINCIPLES

Inheritance.—Individuals derive their several characters from their parents and this is known as 'inheritance'. The fusion of the sperm cell derived from the male parent and the egg cell supplied by the female parent gives rise to individuals. The germ cells pass on the characters of the parents to the progeny. Characters not possessed by either parent cannot be had by the progeny. The transmission and fusion of characters is complex and the character of the progeny cannot always be predicted, even when those of the parents are well known, except when the characters of both the parents are quite alike. Those exhibited by the progeny may be the ones possessed by either parent, with the corresponding character of the other parent suppressed, or a blend of those of both the parents. Thus, if one of the parents is tall and the other short, the progeny may be tall, short or in between the two, though in any case the height character is derived only from the parents. The characters so derived by individuals are called inherited characters. Since they are derived from the parents, choosing and mating suitable parents alone can produce satisfactory progeny.

Variations.—No two living beings are exactly alike in all respects. There are differences between individuals of the same species, which may be brought about by either differences in the inherited make-up of the individuals or in the environmental conditions. The former are heritable and the latter non-heritable. The heritable differences are called 'variations' and the non-heritable ones 'modifications'. In many cases, the differences may be caused by both environmental conditions and inheritance. The difference in the quantity of milk and fat produced by animals may be due partly to feeding and partly to inheritance. It is difficult to separate the effects of the two factors and apportion the share of each.

One of the common differences seen between animals of the same species is due to age, reflected in the size, gait and general appearance. There are also differences between animals of the same age due to the environmental conditions existing in the mother's womb before parturition and maintenance and level of feeding in the early stages of growth. The mother cow may have been famished or affected by diseases during pregnancy and may have given birth to a calf that is weak and does not grow so well as others. The calf itself may be affected by diseases, by the level of nutrition, prevailing climate, etc. The differences brought about in animals by these several factors are modifications, which are not passed on to the progeny. Thus an old bull does not pass on his weakness to the progeny; nor does a young and vigorous bull produce extra vigorous progeny.

Mutation.—Occasionally an individual may be born with characters not possessed by the parents or ancestors. This is caused by changes in the genes, or the carriers of characters, once in a way and is called '*mutation*'. These random changes are very rare and are transmitted to the progeny. The polledness of cattle, or the absence of horns, in certain English breeds like the Aberdeen-Angus, Shorthorns, Red Polls and Herefords sprang as a mutation. It is rather strange that these parallel mutations should spring up in different breeds at different times. Polledness is *dominant* over hornedness, that is, when a polled animal and a horned animal are mated, the progeny are all polled. The horned character is suppressed and is said to be *recessive*. Polled strains have been evolved in many European breeds of cattle, utilising this natural mutation. Mutation is also caused by certain changes in environment like exposure to X-rays, ultra-violet rays, sub-lethal temperature, and treatment with certain chemicals. The animal is a highly specialised organism and random changes in its make-up are not likely to make it more efficient. When desirable changes spring up, the breeder uses such variations for improving the stock. High fat content of milk and high fertility in cattle, which

sprang up as mutations in certain individuals have been utilised in Western countries for building up new strains of animals with the desirable characters. Most natural mutations are unfavourable and favourable ones are comparatively rare. Undesirable mutations should not be perpetuated, by allowing such animals to breed and beget progeny.

Telegony.—There is a belief that the female animal takes impressions of certain characters from the male that first mated with her and that these characters are passed on to all her progeny, even when she is mated with other males subsequently. The illustration generally given is that of a mare that was first mated to a zebra stallion. The mare is said to have produced striped colts subsequently even when mated with ordinary stallions. But this belief is not based on facts. Pincher[17] indicates that ' a mare which had been repeatedly crossed with a donkey and given birth to 13 mule foals in succession was mated to a stallion; the resulting foal was completely normal '. Knowledge of inheritance, theoretical basis and experimental evidence are against this supposition of telegony and it may be dismissed as pure fiction.

Maternal impressions.—The belief is sometimes held that if a cow has in view a good bull at the time of mating, she produces calves like the bull kept in view and not like the one that served. The supposition is that the cow is capable of passing her maternal impressions to the calf. This is also an erroneous belief and there is no basis for it.

Atavism or throw-back.—An offspring is sometimes born with characters not possessed by the parents, but by remote ancestors. This is possible in the case of recessive characters, which do not show themselves, when the corresponding dominant characters are present. In the absence of the dominant factor caused by random assortment of genes, during mating, the recessive character manifests itself. This is referred to as '*atavism*' or '*throw-back*'.

Prepotency.—When a red Sindhi bull is mated to local stock, the resulting progeny are red in colour. The bull is able to impart its colour character to the calf, suppressing

that of the cows. The capacity of the bull to impart his character to the calf, suppressing the corresponding character of the cow, is called '*prepotency*'. Bulls with prepotent economical characters are extremely valuable in breeding. High milk yields and high fat content of milk have been developed in European countries by the use of a few prepotent bulls, for building up these characters in the several breeds.

Pedigree.—The important breeds of cattle in Europe and America have their breed registering associations, where the individuals of the breed are registered and have their milk and beef production capacity recorded. The registers furnish the ancestry of the registered individuals and the records of production of the ancestors. This list of ancestors is known as the '*pedigree*'. Pedigree is genealogy or record of ancestry. Animals that have pedigrees are called '*pure-breds*'. They are animals whose ancestry is thoroughly known, with the productive capacity of the ancestors being carefully recorded, irrespective of the production being high or low. The term 'pure-bred' is a misnomer, as it has no reference to genetic purity, though it implies breed specificness.

Progeny performance tests.—The recording of milk produced by cattle has enabled a proper appraisal being made of the capacity of breeding bulls to transmit their milk characters to their daughters. This is done by what is called the 'progeny performance tests'. The performances of the daughters of a bull are compared with those of their respective dams in these tests. Improvement or fall in the performances of the daughters is taken to be due to the influence of the bull. If the milk and fat producing capacity of the daughters of a bull are consistently higher than those of their dams, the bull is said to be a 'proved' bull.

When progeny performance tests are made, the following precautions have to be taken to ensure the validity of the results obtained:

(1) The performances of the dams and daughters should be compared at the same age. The production of milk

increases with the age of cows, with the peak production being mostly between 5 and 10 years of age. This period varies from breed to breed and country to country. There is a fall in the production of milk, as the cows pass the peak period and advance in age. The actual yield of milk of a large number of individual cows at different ages is tabulated and suitable conversion factors worked out for the different breeds in Western countries. With the use of such conversion factors, the yield of milk at any particular age can be converted to an equivalent yield at any other desired age. The result obtained thus is close to the actual yield and within the limits of probable error. The following conversion factors are furnished by Parmalee Prentice E. for use with Guernsey animals (*Breeding Profitable Dairy Cattle*, 1934, pp. 225).

Table of factors for correcting yields at different ages of Guernsey cows

Age	For milk	For butter fat content	Age	For milk	For butter fat content
2	1·417	0·970	6	1·040	0·990
2½	1·313	0·973	6½	1·025	0·993
3	1·241	0·975	7	1·010	0·995
3½	1·187	0·978	7½	1·005	0·998
4	1·145	0·980	8	1·000	1·000
4½	1·110	0·983	8½	1·000	1·003
5	1·081	0·985	9	1·000	1·005
5½	1·058	0·988	9½	1·000	1·008
			10	1·003	1·010

Similar data have not been gathered and conversion factors worked out for Indian cattle and in their absence, the above data may be taken to give a rough idea of the influence of age on milk yields of Indian cattle. If it is further presumed that Indian cows calve on the average at 3½, 5, 6½, 8, 9½ years and so on at intervals of 1½ years between successive lactations, the peak yield of milk may be expected to be in the fourth and fifth lactations.

The yield of the first three lactations would be 0·84, 0·93 and 0·98 times the peak yield respectively and the corresponding conversion factors for obtaining the peak yield serially from the first three lactation yields would be 1·187, 1·081 and 1·025 roughly.

(2) The milk yields obtained should be corrected to the same period of recording, as for example 305 days, 365 days, etc. A 305-day milk yield is converted to a 365-day milk yield by multiplying it with the factor 1·15.

Similar conversions have to be made, when comparing milk yields obtained by milking the animals varying number of times a day. Cows are ordinarily milked twice a day and when the number of milkings is increased, the quantity of milk produced rises. A twice-a-day milking is converted to thrice-a-day milking by multiplying it by 1·19 and to four times-a-day milking by 1·37. Thrice-a-day milking is converted to four times-a-day milking by multiplying it by 1·15.

(3) The performances of *all* the daughters of a bull should be taken into consideration and not those of certain daughters only. If improvement is seen in the performances of all the daughters tested, the bull may be taken to be capable of improving the production of all his progeny in the future also. If certain daughters alone show improvement over their dams and others register a fall, the bull's transmitting ability cannot be relied upon.

(4) The regularity of calving of the daughters should also be considered, while evaluating the bull.

Breeders look to the pedigree and attach a high value to it. Pedigree is useful, but that alone is not enough, the bull must be capable of transmitting milk, beef and draught qualities to the progeny. This is also desirable in cows. The transmitting ability of the bull can be determined by progeny performance tests. The real value of the bull is known after his daughters start giving milk. Till this is known, he cannot be freely used for serving cows. If he bull has poor transmitting abilities, he should be removed

from breeding and if good, he should be kept on to the very last.

Considerable stress is laid on conducting progeny performance tests in the important dairy countries. Bulls not coming to the standard are removed from breeding and are not allowed to injure and lower the productive capacities of subsequent generations of cattle. There are, however, certain practical difficulties in conducting the test. Trial matings are made when the bulls are $2\frac{1}{2}$ years old. The resulting calves are born after 9 months, the female progeny calve after a further period of $3\frac{1}{2}$ years and another year is required for recording the yields of milk during a lactation of the daughter cows. During this period of 9 months, $3\frac{1}{2}$ years and one year or $5\frac{1}{4}$ years of waiting, the bull could not be used for mating, as his transmitting abilities are not known. The bull will thus be $2\frac{1}{2}$ *plus* $5\frac{1}{4}$ or $7\frac{3}{4}$ years old, by the time it is known whether he is good enough for breeding or not. Bulls may be fit for active service till they are 11 years of age or for a further period of three years. Out of the possible 8 years of breeding life of bulls, 5 years are spent in waiting for the progeny performance test to be completed and 3 years of breeding life alone are utilised. Thus if proved bulls have to be used, 8 of them serving from 8 to 11 years would serve the same number of cows as 3 untested bulls serving from 3 to 11 years of age and the total number of proved bulls required is increased. Against this has to be set off the benefits obtainable by the use of proved sires, resulting in increased production from the whole herd and progressive improvement possible in the general level of the herd.

Artificial insemination.—Artificial insemination is the collection of semen ejected by bulls and introducing it into the womb of cows with special syringes. When the bull mounts over the cow, the bull organ is directed into an artificial vagina, where the ejaculated semen is collected. It is diluted with suitable media and kept preserved in refrigerated storage. It keeps viable for about a week. A small portion

of the diluted semen alone is used with each cow and a single ejaculate of semen can be successfully used for impregnating 15 to 20 cows. A bull can serve 80 to 100 cows a year in the natural way, while he can impregnate 1,000 to 1,500 cows by the adoption of artificial insemination. Its extensive use reduces the number of bulls required for impregnating cows and a much fuller use can be made of specially valuable sires. Bulls are very slow at service after they are 11 years of age, but semen could be extracted from them by physical manipulation, that is, by gently massaging the ampullæ. Thus the breeding life of specially valuable sires can be considerably increased by this method.

The number of cows that can be impregnated by a bull is considerably increased by the use of artificial insemination. The use of poor grade bulls with artificial insemination would increase the scrub stock in the country and the use of good sires would improve the stock appreciably. It is therefore necessary that the very best proved bulls alone are used for artificial insemination. Progeny performance tests are extremely useful when artificial insemination is adopted and not to the same extent when normal mating is done.

Artificial insemination of cows and buffaloes is being done at the Veterinary College, Madras, and some veterinary hospitals in the moffusil. Sindhi, Kangayam, Ongole, Hallikar and Murrah bulls are used. This method of insemination is getting popular with the owners of cows and buffaloes in these places.

CHAPTER V

METHODS OF BREEDING

Breeding is normally confined to animals of the same species and this is classified into three main types, namely: (1) in-breeding, (2) line-breeding and (3) out-crossing.

In-breeding.—This is breeding with close relatives like father and daughter, mother and son, and brother and sister. At least one ancestor appears twice in the last two generations, in the pedigree. In-breeding tends to intensify the several characters possessed by individual animals and leads to uniformity in the herd, particularly when certain individuals and their progeny are repeatedly used in mating. The character of the individuals used for in-breeding is thus fixed in the herd. Individual progeny that do not exhibit these characters are called 'off-types'. In-breeding leads to uniformity in the herd, when it is combined with the removal of the off-types from breeding, and these bring about the 'purification' of the herd.

When in-breeding is continued for some generations using the same animal or its close relatives, and removing the off-types whenever they occur, certain characters that the breeder wants are intensified and the animals raised get pure for those characters. This secures uniformity. In-breeding has been a powerful tool in the hands of capable breeders in other countries in producing very superior animals. All the successful breeds of cattle, poultry and pigs in Western countries have had in-breeding at some stage or other during their evolution. Most of the world famous bulls and cows of to-day have been produced by planned and systematic in-breeding.

It is sometimes said that in-breeding leads to loss of vigour and has therefore to be avoided. In-breeding intensifies both good and weak points. If there is lack of vigour in the constitution, this character is also intensified, there is loss of vigour in the progeny, and this is disastrous.

In-breeding does not by itself undermine vigour or induce other defects. It merely brings out the latent defects inherent in animals. Animals in which defects have thus been intensified have to be weeded out.

Line-breeding.—This is similar to in-breeding in general, but such close relatives are not used as in in-breeding. The mating of cousins, grandfather and grand-daughter, step-brother and sister, and grandmother and grandson are adopted in line-breeding. Here, one ancestor figures twice in the last three generations, but not consecutively. The inclusion of one ancestor within the last 5 generations is generally considered to be the upper limit for line-breeding.

Out-breeding.—When animals not related within the last 5 generations are mated, it is considered out-breeding. Any relationship beyond the fifth generation is treated as no relationship. Out-breeding of a random type leads nowhere. It is generally done with the object of building up certain characters possessed by different individuals within the same breed, but outside the herd.

Mating outside the breed.—This type of mating is known as 'crossing'. It may be (*a*) outside the species, (*b*) with animals of the same species, but outside the breed and (*c*) with animals of reputed breeds to build up good herds from ordinary stock.

(*a*) *Crossing different species.*—The progeny produced by mating animals of different species are known as 'hybrids'. Crossing different species of animals is not always possible; they are not willing to mate and often the chromosomes of different species are not compatible and impregnation does not take place. When hybrids are produced, they are generally sterile and not economically useful. The mule, produced by mating the mare and the jack-ass, however, is a useful hybrid, though sterile. It is hardy and capable of doing heavy work. The European breeds of cattle (*Bos taurus*) and the Indian cattle (*Bos indicus*) cross freely, though they belong to different species. The hybrid progeny of both

the sexes are fertile and cross freely with either parent or among themselves.

The American buffalo (*Bos bison*) has been crossed with Hereford cows (*B. taurus*). The progeny are generally sterile, though occasionally fertile individuals are produced. If a fertile female hybrid is mated to a *taurus* bull and the off-spring back-crossed to a bison bull, the resulting progeny are called ‘ cattaloes ’. They grow rapidly and are able to withstand adverse weather remarkably well. They are also resistant to Texas fever and black quarter.

The hybrids are bigger in size than either parent and more vigorous. This is referred to as ‘ hybrid vigour ’ or ‘ heterosis ’. How exactly the extra vigour is induced is not quite clear. It is not, however, maintained in the subsequent generations that may be continued with fertile individuals.

(*b*) *Crossing different breeds.*—This is sometimes done with the object of building up new breeds and combining the good traits possessed by two or more breeds. It is a laborious process that requires considerable skill in the selection of suitable parents, in culling out the unwanted types of animals, and in fixing the desired traits in the new breed. The English breed of cattle, ‘ the Aberdeen-Angus ’, has been built by the fusion of two separate breeds, the ‘ Aberdeen ’ and the ‘ Angus ’.

When two breeds are crossed, there is ‘ cross vigour ’, just like hybrid vigour, though it is not so pronounced. Such crossing is often done with the object of producing beef stock. Cross-breeding is not generally done with the object of continuing the cross-bred generation of animals. These are of a mixed type and are not ordinarily useful, except for fattening.

When ordinary animals are crossed, superior individuals with outstanding characters are produced occasionally by the combination of certain genes supplied by the two parents, a combination found necessary for the expression of the character concerned. This is called ‘ nicking ’. The superior character is not always passed on to the progeny,

except when the concerned genes pass together in the random shuffling that takes place during mating. Nicking is not of much utility in breeding ordinarily.

(*c*) *Grading-up.*—This is the method used for raising the standard of mongrel stock of cattle by using chosen pure-bred bulls for mating. If a suitable breed is chosen and prepotent bulls are used for mating with scrub cows, continuously for a few generations, the stock is up-graded and the standard is raised. The first generation progeny have 50 per cent. of the superior blood and 50 per cent. of the mongrel blood, that is, the poor blood is halved in one generation. The poor blood is halved again in the next generation and gets reduced to 25 per cent. and later to $12\frac{1}{2}$, $6\frac{1}{4}$ and so forth in the subsequent generations. At the same time, the superior blood in the stock is raised correspondingly to 50, 75, $87\frac{1}{2}$, $93\frac{3}{4}$, $96\frac{7}{8}$, $98\frac{7}{16}$ and so forth. It may be taken that the resulting stock are practically of the superior type from the fifth generation onward.

Selection.—This is the keystone to success in breeding farm animals whatever may be the objective of the breeder and whichever method of breeding may be adopted. When animals are mated, progeny of different make-up and types are born. Some are better than the parents, some are of the same standard, some are below the parental level, and some alone pass their qualities to their progeny. When out of this heterogeneous material, proper individuals are chosen for breeding and retained, and the unwanted animals are removed, improvement in the quality of the herd may be expected. Selection or choosing animals for retention in the herd for mating and production of stock is necessary for building up animals of any desired type or quality. Selection has played a very great part in the production of superior breeds of farm animals all over the world.

In the selection of animals for breeding, conformity to type, pedigree and progeny performance tests have all been found useful aids to the breeder. The conformation of the animal to the type is necessary for producing animals that

are uniform in appearance and productive capacity. The animals that are similar in appearance and type are likely to have the same sets of genes or carriers of character, and uniformity of type in the different generations is an indication of the homozygosity of the stock. Animals of different types would carry dissimilar genes and their inclusion in the herd would produce heterozygous animals, which cannot breed true to type. In this type of selection from the form and appearance of the animals, the aim is the retention of the desired genes, by selecting animals that have the same form or '*pheno-type*'. Uniformity of type is no doubt, desirable but need not necessarily be helpful.

The selection of animals for breeding with the help of conformation of individuals is a hit and miss method. It is not possible to assess the productive capacities of animals by the eye alone. Rice, V. A., indicates that in a guessing contest held in New York State fair in 1919, no one of the 70,000 people who took part was able to place correctly nine cows according to their milk yields. The lactation yields were 4,454 to 20,852 pounds of milk a year, with a range of about 2,000 pounds between each pair of animals. One-third of the people did not even place one cow aright. Some assigned top rank to the poorest milker. Judging the capacity of cows to produce milk by their conformation may therefore be taken to be unreliable.

The selection of animals for breeding by conformation, aided to an extent by observation of their performances, has been going on from early times. Improvement of herd and breeds was brought about gradually by this. But the improvements effected were not very pronounced. The pedigrees of animals were used as guides to selection of breeding animals in the 19th century. The records of the parentage of animals and of the performances of such parents helped breeding practices to an extent. But improvements were not inevitably brought about in the progeny, nor were the improvements always steady; good parents often produced indifferent progeny. The capacity of individual animals

to produce large quantities of milk is not enough by itself. It must be combined with the ability to pass on such productive capacity to the progeny also. If the animals used for breeding are heterozygous with regard to milk characters, the capacity for heavy production may be inherited only by certain progeny and not by others.

Great importance is now attached to progeny performance tests, as a means of determining the homozygosity of the bulls. When an adequate number of daughters of a bull are tested for milk production and when all of them produce milk more than their dams, the increased production is clearly due to the influence of the bull. He is then taken to be homozygous for the milk character. The progeny performance test is thus a test of the genetic purity of the bull, with reference to the milk character. If some daughters alone are better than their dams and others poorer, the bull may be taken to be heterozygous for the milk character. Such bulls are not dependable; they produce different types of progeny that reduce the average herd production and should not be used for further breeding. The progeny performance test provides a method of appraising the value of bulls correctly and is of great value in the selection of suitable breeding stock.

Selection of animals by the performances of the progeny is really the selection of the desired genes. A sound knowledge of animal genetics enables the identification of the genes by comparative studies of the performances of the animals concerned. The selection is then said to be based on '*geno-type*' and is reliable and satisfactory in achieving results more than the selection with the pheno-type as the guide.

What has been said about progeny performance tests for bulls holds good for cows also. Both the bull and the cow are each responsible for half the inheritance of the progeny. Each cow is capable of producing 3 or 4 daughters during her life and trying to appraise the value of the cow with this small sample of daughters is not dependable. Even if it is

granted that her capacity to transmit good production abilities to her daughters could be appraised, she would have passed the breeding age by the time it is known. Such knowledge cannot obviously influence breeding practices. The testing of a bull is different. He produces a large number of daughters, who provide sufficient material for testing his transmitting abilities. The value of proved sires has been increased by the use of artificial insemination. About 1,000 to 1,500 cows could be artificially inseminated by a bull each year and half the progeny are likely to be heifers. A bull may normally be expected to have a breeding life of about five years and he may be able to produce 2,500 to 3,750 heifers and as many bull calves during this period with artificial insemination and 300 to 350 heifers with natural mating. This stresses the need for conducting progeny performance tests properly and selecting good bulls for breeding, in preference to untested bulls.

Improvement of cattle in South India.—Cattle in South India are in a poor state. The production of milk and output of draught power are at a low and unsatisfactory level. The productive capacity is influenced by both heredity and environmental factors, like the prevailing climate, housing, management and feeding. Both heredity and environment play their part in influencing the productive capacities of cattle. The inherent capacity to produce milk and draught power can be raised by breeding and improving the quality of the stock. But that alone would not help. Even when the potential capacity of the animals is raised, production cannot be increased, without at the same time improving feeding and management. This is not fully recognised and stress is often laid unduly on the need for and importance of improving cattle by the adoption of suitable breeding methods.

Cattle raising is a major industry in the country. It has not progressed here as in Western countries. This is mainly because of certain basic limitations inherent in the structure of the cattle industry in this country. It may be

traced to certain environmental conditions associated with the country and the people. The cattle are maintained mostly by small owners and the number of animals maintained in a holding is usually 1 to 3. The owners are not interested in breeding and even if they were, they do not have the necessary facilities. They cannot carry out any breeding programme by themselves. They are not even interested in the proper rearing of calves, except where the calves happen to be male in the case of cows and female in the case of buffaloes, as these could be sold profitably as draught bullocks and milk buffaloes respectively at the adult stage.

It has already been indicated that the production of fodder is limited and that there are more cattle than what the land can reasonably support. The unproductive cattle that are of no use are consuming fodder which could otherwise be used for feeding the productive stock. This accentuates the existing scarcity of fodder. It increases the dry period of cows, reduces the production of milk and the draught capacity of bullocks. The condition of the cattle is thus deplorable and unsatisfactory. Religious sentiment is against the elimination of unwanted cattle and useless stock, and as a result, the cattle industry is running in a vicious circle. It is said that killing cattle is sinful. But the cattle are kept in a semi-starved condition and they lead a life of privation and suffering throughout and have a protracted death, all in the name of humanity. This aspect of the problem deserves dispassionate consideration, without allowing sentiment to cloud the real issue.

The cattle in the country are not sufficient for agricultural work and it is sometimes suggested that their number should therefore be increased. If the existing cattle are not able to do more work, it is largely because they are kept in a poor condition by insufficient and improper feeding and do not therefore have the energy to do more work. This is not generally recognised. Even the present rate of increase is alarming and if by any method a higher rate is induced, it will be disastrous.

Another suggestion that is sometimes made is that the area under fodder crops should be increased and that the feeding of cattle should be rationalised. This is a result of compartmental thinking about one aspect of the problem only, leaving out of consideration other aspects. Side by side with the pressure of cattle population on land, there is the pressure of human population and enough food is not produced for them also. Land cannot be therefore set apart for the production of fodder alone. The crops that are raised have to provide food for human beings and cattle, as at present; there will not then be any competition between their needs, the grains will feed the people and the straw will meet the requirements of cattle. So long as the balance between the available land, the human beings and the cattle is not maintained, it is difficult to see how cattle could be improved. The increase of numbers in cattle and human beings requires to be controlled in some rational manner. It may be stated in the abstract that the only solution is the limitation of the human family and the elimination of the unwanted and sub-standard cattle.

Various field scale experiments under village conditions have shown that proper feeding can increase the production of milk by about 50 per cent. This would apply equally to draught capacity. Rational feeding and adjustment of the cattle population to the available fodder supply will bring about a decided improvement in the condition of cattle and their productivity. Top priority should therefore be given to the regulation of the existing fodder supplies, side by side with the adoption of improved methods of breeding cattle, both by the State and the people. Till this is done, there can not be any real improvement in the cattle industry as a whole.

Breeding better animals has been given a place after feeding, as better animals cannot produce more milk and draught power, without better feeding. Even when the animals have an inherent capacity for high production, it cannot be expressed, till the feed is adequate. Till better

feeding is assured, there is no point in thinking about the production of better breeds of cattle. Taking for granted that better feeding would be provided, how could we set about the improvement of cattle?

What has been done in other countries may perhaps serve as a guide to the formulation of cattle improvement policies here also. The cows in England and Europe were mediocre animals till about the middle of the nineteenth century. Climatic conditions and rainfall favour the growth of grass there and extensive natural grazing is available for a large part of the year, except during winter, when animals are maintained on stall feeding. Spectacular improvements in the quality of cattle, with regard to the production of milk, were effected by reorientating breeding methods. Animals of extreme merit were picked and the desirable qualities of selected animals were fixed, by considerable in-breeding. The best bulls from these herds were later used for mating, so that the average milk production of cows ranges now from 4,000 to 5,000 lb. per lactation. The credit for evolving most of the milk breeds of to-day goes to England and these breeds have been taken to other countries like America, Australia, New Zealand, etc., and improved further. All these have been brought about by the efforts of regular breeders, who produce a sufficient number of pure bred bulls for use. There are no such breeders in this country and it has therefore become necessary for the Government to take up the work of breeding and distributing suitable breeding bulls for use in the villages.

The cows in South India are poor milkers and it is not practicable to import sufficient number of good cows to replace the existing stock. Grading-up local cattle by the use of bulls of a suitable breed from outside the State has some possibilities. If suitable breeding bulls are used for mating for a few generations continuously, the character of the local animals will be changed completely in 4 to 5 generations and within a measurable period of time. The local stock will then become a new breed practically, almost

as good as the superior breed from which bulls are drawn for grading. When the superior blood is raised to seven-eighths or more in the graded-up bulls, they can be used for breeding, and importing bulls for further mating would not be necessary. Securing a sufficient number of bulls of the superior breed for use on a country-wide scale may not be possible immediately. So, to start with, small sections of the country may be taken up as units for operation and the units shifted to new areas after each period of ten years. Artificial insemination can be of great assistance, when such large-scale breeding programmes are carried out.

The hurdles in grading-up.—It has been indicated that scrub cattle could be graded up successfully in a short time. Certain practical difficulties may, however, crop up. The unsatisfactory result of crossing the local stock with Ayre-shires has already been indicated. It has been shown how disastrous such unsuitable crossing could be, when the breed chosen is not able to thrive under the exacting climatic conditions prevailing here.

Sindhi animals have been introduced successfully in all parts of India for improving the milk supply in cities and the milk-producing capacity of local cows. Sindhis are the best milkers in India and they thrive under the various climatic conditions that prevail in different parts of the country. But the Sindhi grade bullocks are slow at work like their Sindhi parents and do not find favour with the South Indian peasant. If Sindhis are used for grading local stock, there would be improvement in milk qualities, along with a fall in draught values. To the peasant, draught is more important than milk. Any grading-up for improvement of milk should not therefore overlook the need for maintining draught values.

Whether there are European breeds of cattle other than Ayreshires that could be used for grading up South Indian stock is a question, to which a satisfactory answer cannot be furnished readily, without first introducing bulls of different breeds and making test matings. Indian breeds like the

Tharparkars and the Hariana that combine both draught and milk qualities may perhaps be more suitable for grading up the South Indian cattle. How far this progeny would thrive and be satisfactory has to be determined by actual trials before large-scale adoption of this crossing. Such trials have to be undertaken by the State itself, in the interests of the country and not left to private individuals, where personal profit may be a more dominant motive than reliability of trials and their findings. The grading-up is for the benefit of the peasant and it is necessary that his exact requirements and the facilities he has should receive due consideration. This is likely to be forgotten in State enterprises and what the scientist or the administrator considers should benefit the peasant more may receive greater attention. This has to be guarded against.

The improvement of cattle in South India may also be viewed from another angle. Would it be possible to develop two types of animals, one for meeting the urban milk supply and the other for supplying draught power for the peasant, side by side, as in the West? For example, in England, there are dairy shorthorns and beef type shorthorns, two types within the same breed or two sub-breeds. If milk and draught types are evolved side by side separately, the utilisation of bullocks of the milk type and cows of the draught type raise practical difficulties. The bullocks of the milk type may be poor draught animals and the cows of the draught type may be very poor milkers. These animals would be an economic liability; and here in India, for various reasons, these animals are not removed by slaughtering for beef as in other countries.

From a consideration of the foregoing, a few principles may perhaps be laid down for guidance with regard to the improvement of livestock either by crossing or grading, based on the experience gained here as well as in other countries:

(1) The stock introduced for grading or crossing should be capable of thriving under the local conditions of climate, environment and feeding,

(2) The stock produced should satisfy the requirements of the peasants and the people in general, namely the male stock should have good draught capacities and the female stock should be good milkers, and

(3) Side by side with improved breeding, feeding also should be improved, so that the potentialities of the stock produced may be realised to the full.

Taking all these into consideration, it may perhaps be suggested that the suitability of Indian breeds of cattle having both milk and draught qualities should first be ascertained and such breeds used for grading up the local Indian cattle. At the same time, development of local stock by selection and the building up of milk breeds by grading-up should be undertaken. This will naturally take a long time and the results obtained may not be spectacular, as improvement of livestock by breeding is by its nature very slow. Possibilities of introducing suitable European breeds of cattle for improving the local stock by crossing may also be kept in view.

CHAPTER VI

JUDGING CATTLE

Judging cattle is an art that is acquired by constant association and familiarity with cattle and getting fixed in one's mind the several points that contribute to excellence in cattle, and that do not admit of objective physical measurement. It has been seen that judging cows by conformation is liable to wide variations and error, as absolute standards of measurement cannot be prescribed for the several points and the personal bias of the observer largely influences such judgment. Judging cattle is therefore difficult and lacks precision. All the same, visual examination and judgment have some value and it is all that is possible in many cases.

Before learning judging, one has to acquire an idea of the standard of each type, breed and class of animal and the several points that constitute an ideal animal. Every animal one meets with may then be compared with the standard that one has in mind, and the variations appraised. As one gets trained in making such comparisons, his capacity to form quick and accurate judgment is developed. Mastery of the art of judging is acquired by close association with cattle and long experience. Something akin to a shepherd's instinct and quick perception has to be acquired in judging cattle. If one sheep is removed from a flock and replaced by another when the shepherd is away, the loss of his sheep is the first thing he notices when he returns, by running his eye over the flock in one sweeping glance. Almost close on this, he notes that one outside sheep has strayed and mixed with his flock. He does not make any conscious effort to count his sheep and see whether all his sheep A to Z are there. The whole thing is perceived in one glance. This faculty has been developed by close association with sheep for years and a genuine love for animals. Similarly, appraisal of the quality of cattle requires years of training, close association and a genuine love for cattle.

Judging bulls and draught bullocks.—The capacity to pull heavy loads at a fairly fast rate is what is desired in draught animals. Whether those anatomical characters that aid in giving this propelling power are present in the animals requires to be examined. The neck of the bullock takes the load and a thick neck denotes heavy draught capacity, while a thin, slender and sinewy neck denotes speed. If the flanks and hind quarters are properly muscled, the animals may be taken to have good propelling power. The size of the muscles in the hind quarters is roughly indicative of the power the animal can exert, while its length is an indication of the speed of the animal.

An animal that keeps its head erect when standing squarely on level ground is alert and brisk at work. Such animals have expressive eyes and their nostrils are wide and distended. An animal which tends to lower its head while standing, is apt to be slovenly at work.

The firmness of the muscles is an important point in cattle. Well formed, good sized, firm muscles are indicative of strength, endurance and a spirited nature, while loose flabby muscles go with slovenliness, and lack of strength and endurance. The quality of the muscles can be ascertained by feeling them. When the fingers are thrust in between the ribs on the sides, firm muscles offer considerable resistance and the fingers do not get in far between the ribs. When the muscles are thin and loose, the fingers work into the ribs easily. Pressing the muscles against the ribs with the palm of the hand also gives an idea of the thickness and firmness of the muscles. The quality of the muscles of the back, flanks and hind quarters may also be judged similarly.

The skin near the ribs is easily picked up with the fingers with loosely built animals and only with difficulty from tight skinned animals. A tight skin goes with great sensitivity and fiery temper, while loose skins go with slovenliness and placidity in work bullocks.

After examining the various points of the animals when they are stationary, they may be made to walk slow and also

trotted to get an idea of the movement of the legs. When an animal is examined from the front, it may be noted whether (1) he carries his head well up, (2) the stride is regular, and (3) the feet are lifted clearly off the ground evenly. If the forelimbs are not properly shaped, the line passing through the shoulder, the centre of the knee and the centre of the foot is not straight and vertical, the front pasterns knock against each other and the animals get fatigued easily. Such animals may be devoid of hairs on the inside of the pastern and may even have sores.

When an animal in motion is seen from the side, the fore and hind legs must work in unison. When viewed from behind, the flexion about the hock should be free and straight, without any side pull, drawl or knocking of the hock. These are indicative of weakness of a side or want of proper conformation of the leg bones. The main points of conformation of the different parts of the draught animals are given below:

The head.—The nostrils should be wide; the eyes prominent; the ears long, pointed and alert, and the horns fine textured without any tendency to split.

The neck should be muscular and strong.

The shoulders should be full, strong, sloping and muscular. Moderate obliqueness favours a quick step. Straightness, on the other hand, tends to make the step short.

The chest should be deep and broad.

The fore legs.—A vertical line in front from the point of the shoulder should fall on the centre of the knee, cannon, pastern and foot. From the side, a vertical line from the centre of the elbow should fall on the knee and pastern joints and the back of the foot, and another from the middle of the foreleg should fall upon the centre of the foot.

The hocks should be fairly wide set. From the side, a vertical line from the hip joint should fall on the centre of the foot, and another from the buttock should coincide with the angle of the hock and pastern joints. From the rear, a vertical line from the buttock should pass through the centre of the hock, cannon, pastern and foot.

The feet should be hard, black and waxy. The two halves should be even and the cleft of the hooves narrow.

The body should be short, with broad back and deep ribs. The length of the body goes with speed.

The loins should be thick and broad. The croup should be fairly broad and well muscled.

Judging in show rings.—A number of animals are entered for judging in show rings. They are made to walk round a circular path, called the show ring, when glaring defects in the conformation and gait of the animals can be noted and the defective animals eliminated from the contest. A few animals that are finally left behind in the ring have now to be placed serially according to the order of merit. Competitive judging is done at this stage, by noting the several good points of each animal. Marks are assigned individually for the several points that make up the draught qualities and the animals are placed in the order of merit, with the total marks obtained by the different animals as the basis. The score card for the award of marks may be drawn in different ways according to the purpose for which the animals are judged. One such score card is given below, to serve as illustration:

SCORE CARD FOR JUDGING DRAUGHT BULLOCKS

1) *General appearance—20 points*

Height behind the hump and size	8
Form: deep and symmetrical	4
Quality: bones and joints clearly formed ..	4
Carriage and disposition	4

2) *Head and neck—12 points*

Head: well shaped and true to breed	2
Ears: long and capable of flapping the eyes ..	1
Eyes: large, prominent and expressive	2
Muzzle: large; mouth wide; nostrils wide ..	2
Horns: shaped true to breed	1
Neck: long and strong with good dewlap ..	4

(3) *Fore quarters—20 points*

Shoulders: deep, sloping and sturdy	3
Hump: well developed	2
Forelegs: well muscled, set square	5
Knees: straight and broad	1
Cannons: bones ample sized and broad ..	2
Fetlock: straight and broad	1
Pastern: moderately long	2
Feet: black and waxy with narrow cleft ..	4

(4) *Body—12 points*

Back: strong and straight	4
Loins: short, broad and strong	4
Chest: deep and broad with well sprung ribs ..	4

(5) *Hind quarters—26 points*

Hips: broad	1
Rump: well muscled	3
Tail: thin, well set, long and tapering	2
Thighs: deep, wide and full	3
Hocks: fairly wide apart	2
Cannons: broad, short, flat and clean	3
Fetlock: well formed	3
Pastern: well formed	1
Feet: large with narrow clefts	2
Hind legs: set square	3
Buttocks: well rounded and broad	3

(6) *Action—10 points*

Walk: free and regular with easy gait	6
Trot: energetic and rapid	4

Judging cows.—It has already been indicated that judging cows by their conformation, or what are called milk characters, is not satisfactory and they are best judged by their milk and fat production records. Where previous records are not available, measuring the production of milk and fat for short periods may also give a fair idea of the potentiality of cows. They are generally purchased in this

country within a fortnight of calving and the milk yielded by them in a period of 24 hours is measured and their potential capacity is judged. The dealers stimulate the secretion of milk temporarily by special feeding and the milk yield falls down by 20 to 25 per cent. after purchase.

In the dairy shows of the Western countries, the cows are generally tested for the production of milk and fat for two consecutive days. The following is one system of awarding points that is in vogue.

For constitution and conformation ..	20 points
For each pound of milk produced daily ..	1 ,,
For each pound of fat produced daily ..	20 ,,
For each pound of solids-not-fat ..	4 ,,
For each 10 days of lactation up to a maximum of 20 points	1 ,,
For each per cent. of fat less than 3 per cent., deduct	10 ,,

Dry cows without previous production records have to be judged by conformation only. The conformation of good milkers is patterned along certain definite lines. Though the secretion of milk is a natural process, its production developed to a great extent by selective breeding, rearing and management has modified the body conformation to suit the increased milk production. This can be easily seen when good milkers are kept by the side of poor milkers. The secretion of milk has developed the parts of the cow that are associated with milk production. The digestive and lacteal systems are considerably developed, which gives a wedge shape to the cow. The body tapers from the back to the front. The stomach region is deeper and wider than the chest. The development of a capacious udder accentuates the wedge. A pronounced stomach and udder development is indicative of the capacity to digest large quantities of feed and convert it to milk.

The milk is elaborated from the blood by the alveolar tissue and large quantities of blood have to pass through the udder. A vigorous circulatory system is associated with

a strong nervous system and generous secretion of milk. There are no external characters, which are directly indicative of this vigour. The constitution of the animal, and efficient digestive and lacteal systems may be taken to be indicative of the efficiency of the circulatory and nervous systems.

The following features are associated with good milkers:

Dairy conformation.—Cows are said to have a good dairy conformation, when they have a pronounced wedge shape developed along the horizontal and vertical planes. This is normally indicative of good milking abilities.

The udder should be capacious and attached high up between the thighs and extend forward towards the navel. It should be soft, pliable and should collapse after milking. Fleshy udders that retain their shape after milking do not have much storage space for milk and do not secrete much milk. The udder should be flat on the underside and rounded behind. A flat rump, wide hip bones and hocks give room for the development of capacious udders. The skin should be fine and the hair on the udder silky to the feel. The teats should be well spaced and be of good size.

The milk veins on the under-belly leaving the udder should be thick, prominent, tortuous and well branched.

The dewlap should be large and hang in graceful folds. A generous dewlap and a prominent loose navel flap of hanging skin commonly characterise good milkers in *indicus* cows. *The croup* should be hollow from the point of the hip to the base of the tail.

The general appearance of the cow gives an idea of her vigour, health and capacity. It is desirable that the cow has a gentle docile look and a mild temperament. The head should be fine and have a feminine look. The eyes should be mild, denoting gentle disposition, and bright, indicating vigorous health and active circulation of the blood. Nostrils should be wide and distended. The ears should be long and capable of flapping the eyes. The neck should be thin and fine; thickness of neck goes with good

beef qualities. The thighs should be long and lean and the flanks thin; short, thick and fleshy thighs characterise beefy types.

A good dairy cow has a loose-knit frame without any tendency to lay on fat, indicating that all the energy of the animal is directed towards the production of milk.

When cows are judged by conformation, without testing their milking, marks are awarded for the several features that constitute the milk characters and this may be done in many ways. One sample score card is given below for illustration:

Score Card for Judging Dairy Cows

(1) *Dairy conformation*—15 *points*	
Clear cut feminine appearance, absence of tendency to lay fat and gentle look	5
Shoulders, withers, vertebræ, hips and pin bones prominent and free from fleshiness	4
Loins: wide	3
Ribs: long and wide apart	3
(2) *Digestive capacity*—15 *points*	
Muzzle: large and mouth broad	1
Skin: mellow and loose with medium thickness, indicating good circulation of blood; hair soft	4
Barrel: deep, wide and long, well supported ribs set apart, extending onward from the back bone and well arched	10
(3) *Constitution*—15 *points*	
Chest: deep and broad, with well sprung ribs ..	8
Nostrils: large and open	2
Thriftiness in look and vigour with good flesh ..	5
(4) *Milk secretion*—35 *points*	
Udder: large and capacious	8
Udder: collapsible and freedom from solidity ..	8
Udder rounded behind, flat under and set well forward towards the navel and backward between	

the thighs and high up without being pendulous; quarters full and symmetrical	6
Milk veins large, numerous, well branched, tortuous and prominent	8
Teats well spaced uniformly, set square, large in size and convenient for handling	5

(5) *Style and general appearance*—20 *points*

Head: erect and elegant; neck slender ..	3
Back: straight and strong	4
Hips: wide apart and level	3
Rump: long, wide and level	5
Tail: set level with good length	2
Legs: straight and cleanly formed with good bones	3

CHAPTER VII

PRINCIPLES OF FEEDING

The use of food.—The food that is consumed and digested is used by animals for providing them with the energy necessary for maintaining the body temperature, for carrying on the various life processes like muscular movement, digestion of the feed, blood circulation, etc., and for furnishing the materials necessary for renewing the body cells. All these processes are carried on by the animal right through life. The feed required for carrying on the bodily functions is called the '*maintenance ration*'. Feed is also utilised for other purposes, such as growth in young animals, development of the fœtus in pregnant cows, muscular activity associated with work, production of milk, meat, wool, etc. The portion of the feed that is used for these purposes is called the '*productive ration*'.

Nutrients.—The essential ingredients present in the animal system and in the animal feed provided by plants are essentially the same, namely carbohydrates, fats, protein and minerals, which are called '*nutrients*'. There is, however, one main difference between plant and animal tissues. The plant tissues are mostly made up of carbohydrates, while the animal tissues are mostly made of protein, together with varying proportions of other ingredients. The nutrients have specific and definite functions connected with the animal system. The fats and carbohydrates are energy producers and the fats produce about 2·25 times as much energy as carbohydrates. The protein is used for the growth of muscles and other tissues in the animal body, for the production of milk, wool, etc., and for the renewal of body cells, wasted in the various metabolic processes. If protein is given liberally over and above the requirements of the body, the excess protein is used for the production of energy. Thus while protein may sometimes function like fats and carbohydrates by supplying energy,

other nutrients are not capable of promoting growth like protein. It is therefore necessary that protein is supplied to animals to meet their full requirements. It is the costliest of the nutrients and economic considerations require that it is supplied just to the extent necessary and no more.

Minerals are required in small quantities for providing the necessary elements like calcium, phosphorus, sodium, chlorine, etc., for the formation of bones and the maintenance of the mineral balance and the level of acidity of the tissue fluids.

Calcium and phosphorus.—Inadequate supplies of calcium and phosphorus in the feed may be partly responsible for the long dry periods and short lactation of Indian cows. When calcium and phosphorus in the feed are insufficient, cows withdraw from their system the necessary quantities of these minerals and maintain the normal composition of the milk secreted by them. When the animal system is unable to supply the minerals any further, the secretion of milk is reduced and stopped eventually, leading to a lowered daily milk yield and a short lactation period, out of the cow's inability to part with more of body calcium and phosphorus. The dry period of the cow is thus started with a low body calcium and phosphorus, and it takes some time for her to recoup and come to heat. The general low level of feeding is also responsible for this condition. This explains why Indian cows have long dry periods. After conception, calcium and phosphorus are required for building up the body reserves of the cow and for forming the bones of the fœtus. If the feed is poor, the body calcium and phosphorus are again drawn upon, now for forming the bones of the fœtus. Supplying sufficient quantities of these elements during pregnancy therefore assumes importance. If at calving, the cow starts with low body calcium and phosphorus reserves, it affects the yield of milk and the length of the lactation. Sufficient quantities of calcium and phosphorus are necessary during pregnancy and lactation, to enable the inherent capacity of cows to be expressed to the fullest extent, with regard

to the yield of milk, the length of the lactation and the reduction of the dry period.

Sodium and chlorine.—Common salt is supplied regularly with concentrated feed to cattle in Western countries. It serves as a condiment and a nutrient, improving the salivary secretion and the activity of diastatic enzymes. It promotes appetite, thriftiness of the animal and secretion of milk. Sodium chloride is an important constituent of the blood and tissue fluids and regulates their level of acidity. It is needed for the production of hydrochloric acid in the stomach, which is necessary for digestion. Sodium and chlorine are excreted through urine mainly and through perspiration. The latter may be great, when animals are at heavy work during hot weather.

Cattle seem to be capable of adjusting themselves to the supply of salt naturally available in the feed and cows producing small quantities of milk and bullocks may not suffer from deprivation of salt in the feed, as is seen in South India. The feed is possibly able to meet the requirements of the animal system. Heavy milkers in Western countries seem to be affected adversely if salt is withheld from the feed; there is loss of appetite and thriftiness, and reduction of body weight and yield of milk. Salt may be added to the feed in this country also with benefit; feeding and milk secretion may improve. Blocks of rock salt kept in shallow trays in calf pens and cattle sheds are licked by animals and this is an indication of the need for salt felt by them.

Coefficient of digestibility.—Not all the feed consumed is digested and assimilated by animals. The portion of the feed that is not digested is voided as fæces. By analysing the feed given and the dung voided, the amount of nutrients digested and assimilated by an animal is ascertained. When it is represented as a percentage of the nutrients supplied in the feed, it is known as the '*coefficient of digestibility*'. It may be stated in a general way that as the proportion of fibre in the feed decreases and that of the nutrient increases, there is a rise in the proportion of the nutrients digested.

Thus in a rich material like groundnut cake, the protein is digested to a greater extent than in rice straw, which is a very poor material. The digestible nutrients alone provide nutrition to the animals. The undigested material increases the bulk of the feed and it is expelled from the animal system as foreign matter, in the form of dung.

Nutritive ratio.—The ratio of digestible protein to the total digestible carbohydrates is called the nutritive or albuminoid ratio. For this purpose, fat is classed with carbohydrates. Fat supplies 2·25 times as much energy as carbohydrates and the digestible fat is multiplied by 2·25 and added to the digestible carbohydrates, to obtain the total digestible carbohydrates, for the determination of the nutritive ratio. This ratio is a measure of the richness of protein in the feed; the narrower it is, the richer is the feed. Thus groundnut cake with a nutritive ratio of 1 : 0·7 is richer than gingelly cake with a ratio of 1 : 1. The cereal straws have wide nutritive ratios of 1 : 25 to 1 : 40 and contain very little of protein. The number of parts of total digestible carbohydrates present for every part of digestible protein in the material also expresses the proportion of these two nutrients and it is a convenient form of expressing the nutritive ratio. Thus groundnut cake and gingelly cakes may be said to have nutritive ratios of 0·7 and 1·0 respectively.

The nutritive ratio of the total feed, including both roughages and concentrates, required for feeding different classes of cattle is variable. The nutritive ratio that is more or less suitable for dry cows and bullocks is 10, for growing animals 5 to 6 and for milch cows 6 to 7. When rich feeds with narrow nutritive ratios are provided to animals, the protein over and above the body requirements is utilised for the production of energy and this is not economic. When poor feeds with low nutritive ratios are supplied, animals do not get sufficient protein and that required for metabolic activities is drawn from the animal system and they get thin and lose condition.

The Starch equivalent (S.E.)—The starch equivalent of a feeding material represents the number of parts of pure starch, which on being added to the maintenance ration is capable of producing the same amount of fat (or energy) in an animal as 100 parts of the feeding material under consideration. Theoretically, this must be equal to the fat-producing value of the digestible nutrients in the feed and the following may be taken as the basis for the calculation of the starch equivalent:

1 part of digestible protein = 0·94 parts of S.E.,
1 part of digestible fat = 2·20 parts of S.E., on the average,
1 part of digestible carbohydrates = 1·00 parts of S.E., and
1 part of digestible crude fibre = 1·00 parts of S.E.

When the starch equivalent of the digestible nutrients are added, the sum gives the starch equivalent, according to the assumptions made above. On actual feeding, it is seen that the real starch value obtained is much less. It is so because, considerable energy is used in digesting materials containing crude fibre and the energy used for digestion does not become available for putting on fat. The difference between the calculated and the actual values represents the energy used for digestion. This depression of the starch value is related to the crude fibre content of the feed.

For obtaining the actual or real starch values, further deductions have to be made. These are in proportion to the total crude fibre content of the feeding material on the following basis. The deduction made for every per cent. of total crude fibre in green fodder is 0·58, when it is 16 per cent. or more and 0·29 when it is 4 per cent. or less. When it is between 4 and 16 per cent., the deduction factor is raised in proportion to the fibre percentage over 4, that is, by 0·29/(16 − 4) or 0·29/12, or 0·024 for every per cent. of crude fibre over 4. Thus, when the crude fibre content is 11 per cent., the deduction is (11 − 4) × 0·024 + 0·29 or 0·458 for every per cent. of crude fibre, with a total deduction of

5·038. The deduction made for dry fodder is 0·58 for every per cent. of crude fibre uniformly.

Deposition of fat in the animal system is one aspect of the capacity of a feeding material; providing energy is another. Starch equivalent is the capacity to lay on fat and similarly the energy value of a feed is its capacity to produce energy in the animal system and both these are directly related to each other. Energy value is expressed in calories and one pound of starch equivalent is equal to 1,071 calories.

Feeding standard.—This is the scale of digestible nutrients, that meets the daily dietary requirements of the different classes of animals. An animal at rest and doing no work requires small amounts of nutrients only. Additional nutrients are required for animals doing work, or that are lactating, in proportion to the milk produced. Nutrients required for the maintenance of the animal system and additional nutrients required to be supplied over and above the maintenance ration for the production of milk and for doing work are given below:

Nutrients required for maintenance of adult cattle per head per day

Live weight in pounds	Digestible crude protein	Starch equivalent
500	0·338	3·05
600	0·399	3·58
700	0·458	4·09
800	0·516	4·59
900	0·570	5·08
1,000	0·625	5·57

Source: *Mis. Bull. No.* 25, 1952,, *I.C.A.R., New Delhi.*

Nutrients required for the production of a pound of milk, to be added to the maintenance allowance

Fat per cent. in milk	Digestible crude protein	Starch equivalent
3·0	0·040	0·233
4·0	0·045	0·275
5·0	0·051	0·316
6·0	0·057	0·357
7·0	0·063	0·398
8·0	0·069	0·439
9·0	0·075	0·480
10·0	0·081	0·521
11·0	0·086	0·562

Source: *Miss. Bull. No.* 25, 1952, *I.C.A.R., New Delhi.*

Nutrients required for production of work, per 1,000 *lb. live weight, to be added to the maintenance allowance*

Nature of work	Digestible crude protein	Starch equivalent	Duration of work
Heavy	1·5	13·12	8 hours a day
Medium	0·9	6·56	4 hours a day
Light	0·5	3·29	2 hours a day

Source: *Miss. Bull. No.* 25, 1952, *I.C.A.R., New Delhi.*

Rations.—The schedule of feed of different kinds supplied daily to animals is commonly referred to as ' rations '. When the various digestible nutrients in a ration are in the proportion required by the animal system, it is said to be a ' balanced ration '. In practice, animals are provided with concentrated feed according to the schedule of rations and as much of rough fodder as they would consume. The quantity of feed an animal consumes in a day ranges from 2 to 2½ lb.

of dry matter for every 100 lb. live weight of the animal. Animals doing heavy work or producing large quantities of milk have well developed digestive systems and consume more dry matter than poor milkers or animals at rest. Animals of the former class require large quantities of nutrients, which could not be supplied by rough fodder alone. They are therefore given concentrated feed, which are rich in nutrients. Since the capacity of animals to take in dry matter is limited, a large part of the total feed consists of concentrates, with cows producing large quantities of milk. A cow weighing 800 lb. can consume 16 to 20 lb. of dry matter per day. If she produces 25 lb. of milk daily, she requires 8 lb. of concentrated feed for the production of milk and 3 lb. for maintenance or a total of 11 lb. of concentrates. Her capacity to consume dry fodder is limited to 16 to 20 *minus* 11, or 5 to 9 lb. only. If she is dry, she is given 3 lb. of concentrates and can then consume 13 to 17 lb. of dry fodder. A large part of feed consists of roughages with dry cows, working bullocks and poor milkers with the concentrates forming only a small part of the total feed.

Roughages and concentrates.—The feed given to cattle can be divided into roughages and concentrates. The straws of cereals would represent the roughage group. They are fibrous, coarse and low in nutrient content in general. They have feeding value in that the bacteria of the rumen can utilise them to form products, which the animals can metabolise. They help to maintain the muscular and nervous tone of the alimentary system and aid peristalsis. Cattle in India are largely maintained on roughage feeding and concentrates are given only to superior work bullocks and milch animals.

The concentrated feeds are represented by cotton-seed, oilcakes, cereal grains, bran, etc., which are rich in one or more of the nutrients. The concentrated feeding materials are costly and are used for balancing the feed, that is, supplying the animals with the nutrients that are lacking in the roughages. The concentrates are less bulky when compared to the roughages and are suitable for feeding heavy milkers, which make a large demand on nutrients.

The following schedule of rations in use at the Agricultural College, Coimbatore, has been found to be satisfactory. The concentrated feed mixture is made up of equal parts of groundnut cake, cotton-seed, rice bran and *dhall* husk. One pound of the mixture contains 0·158 lb. of digestible protein and 0·57 lb. of starch equivalent.

Kind of animal	Groundnut cake	*Dhall* husk	Cotton-seed	Rice bran	Mineral mixture	Salt	Digestible protein	Starch equivalent
	lb.	lb.	lb.	lb.	oz.	oz.	lb.	lb.
Work bullocks ..	2	..	1½	..	1	1	0·589	2·0
Breeding bulls ..	1¼	1¼	1¼	1¼	2	2	0·79	2·85
Dry cows ..	¾	¾	¾	¾	2	2	0·47	1·71
Cows giving milk—								
1. over 30 lb. ..	2½	2½	2½	2½	2	2	1·58	5·70
2. 25–30 ,, ..	2¼	2¼	2¼	2¼	2	2	1·42	5·13
3. 20–25 ,, ..	2	2	2	2	2	2	1·27	4·56
4. 15–20 ,, ..	1¾	1¾	1¾	1¾	2	2	1·11	4·00
5. 10–15 ,, ..	1½	1½	1½	1½	2	2	0·95	3·42
6. 5–10 ,, ..	1¼	1¼	1¼	1¼	2	2	0·79	2·85
Cows nearing parturition ..	1	1	1	1	2	2	0·63	2·28
Calves—								
1 year old ..	1	1	1	1	1	1	0·63	2·28
10–12 months ..	¾	¾	¾	¾	½	1	0·47	1·71
7– 9 months ..	⅝	⅝	⅝	⅝	½	1	0·40	1·43

Some Feeding Hints

Protein.—Cows are efficient in converting protein supplied in the feed to milk and require to be fed digestible protein at 1·25 times the quantity secreted in milk. Since protein is the costliest of the nutrients, farm grown protein may be used to the maximum extent possible. Legume feed, particularly hays such as lucerne and sunhemp can replace concentrates to a large extent in the case of poor and medium milkers.

Fats and carbohydrates.—These are interconvertible and the deficiency of one in the feed is made up by an equivalent quantity of the other. Still, a supply of at least 4 per cent. of fat in the concentrates is considered necessary for maintaining the efficiency of animals in producing milk and in work.

Minerals.—The common roughages do not supply calcium and phosphorus for meeting the full requirements of productive stock. The concentrates supply sufficient phosphorus in general, but not calcium. Leguminous feeds are rich in calcium and to a smaller extent in phosphorus also, and where leguminous feeds are not regularly supplied, the feed may be supplemented with mineral mixture, consisting of equal parts of shell meal and sterilised bone flour, at one ounce per head per day for bullocks and two ounces for cows and growing animals. Common salt may also be added to the concentrates, according to the schedule of rations furnished already. Where large herds are kept, it is convenient to make up the mineral mixture with two parts of common salt, one part of sterilised bone flour and one part of shell meal and supply it with concentrates at the level of three per cent. of the concentrated feed. Rock-salt blocks may also be kept in calf pens, so that the calves can lick the salt, when required, for supplementing the salt in the feed.

Mixed feeds.—Though suitable rations can be made up with a single concentrated feeding material for meeting the dietary requirements of cattle, it is an advantage to employ three or more varieties of feeds. Mixed feeds are relished by the animals better and they are readily consumed. It would be enough if the feed is made with commonly available feeding stuffs like cotton-seed, groundnut cake, *dhall* husk, rice bran, etc. A rough and ready guide is three pounds of concentrates per day for the maintenance of animals and three additional pounds for every gallon (10 lb.) of milk produced.

The composition and digestibility of the common feeds available in South India are furnished below:

Percentage composition of the common South Indian feeding stuffs

Name of feed	On a dry basis					Nutritive ratio	Digestible nutrients in 100 lb. of raw material	
	Ash	Crude protein	Fat	Fibre	Carbo-hydrates		Digestible protein	Starch equivalent
				A. Straws				
Rice	18·08	3·71	1·62	33·81	42·00	138	0·31	28·9*
Sorghum	9·26	4·33	1·71	32·91	51·59	209	0·41	33·3*
Ragi (*ragulu*)	13·46	2·43	2·63	31·22	49·82	359	0·22	32·3*
Cumbu (*Sajja*)	8·66	2·09	1·43	40·50	47·20	444	0·19	32·6*
Tenai (*Korra*)	12·66	4·04	2·14	35·96	45·19	219	0·34	31·5*
Varagu (*Arika*)	11·01	2·16	2·75	31·59	52·37	250	0·20	34·0*
				B. Hays and silage				
Hariali hay	14·97	11·06	1·92	25·86	46·19	5·7	7·28	34·8
Sunhemp hay	7·20	14·88	1·16	43·55	33·21	4·0	9·40	20·5*
Kolakattai hay	12·70	10·00	1·16	35·33	42·60	9·2	4·94	31·7
Groundnut haulms ..	13·22	10·73	0·88	42·69	32·41	5·5	6·76	17·7*
Groundnut hay ..	14·81	21·51	0·95	24·54	38·19	2·3	13·44	30·4

Percentage composition of the common South Indian feeding stuffs—(Continued)

Name of feed	On a dry basis					Nutritive ratio	Digestible nutrients in 100 lb. of raw material	
	Ash	Crude protein	Fat	Fibre	Carbo-hydrates		Digestible protein	Starch equivalent
Horsegram hay	13·09	10·56	1·81	16·20	58·34	6·0	5·21	37·1*
Ragi straw silage ..	15·03	15·81	4·99	30·00	34·14	30·0	0·09	9·0*
			C. Green feeds					
Hariali, young	12·58	21·94	2·71	18·63	44·14	4·0	2·58	12·8
,, prime	12·65	10·04	1·42	31·89	44·01	10·6	1·11	12·0
,, mature	7·79	4·90	1·50	39·74	46·07	43·0	0·31	12·4
Guinea grass	13·87	7·69	1·67	37·33	39·44	10·2	1·46	10·6
Napier grass	16·70	5·35	1·89	31·90	44·16	13·5	0·96	9·6
Fodder, sorghum ..	9·40	8·91	2·14	35·13	44·42	11·9	1·03	10·0
,, maize	8·15	6·74	2·09	35·95	47·07	13·5	1·17	13·1
Sweet potato vine ..	10·37	14·09	3·72	29·77	49·05	4·5	2·29	9·8*
Sun flower plants ..	15·38	11·94	3·44	23·98	45·26	5·1	2·14	9·4
Sugarcane top	6·09	2·64	1·36	31·18	52·73	34·0	1·64	11·4

Lucerne	10·69	20·24	2·32	30·13	36·62	2·4	14·73	33·9
Agathi (avisi)	12·40	33·56	5·60	8·80	47·20	1·7	6·71	16·5*
Pillipesara	15·01	12·79	1·41	24·71	46·41	4·7	2·56	12·0*
Water hyacinth	16·47	6·54	1·70	24·70	50·59	..	..	..
			D. Concentrates					
Groundnut cake, expeller	5·70	51·75	8·22	7·39	26·94	0·7	41·75	68·3
Groundnut cake, chekku	6·08	54·30	12·46	4·22	22·81	0·8	43·98	78·9
Coconut cake, expeller ..	6·48	25·34	8·20	13·20	44·92	2·7	20·53	75·4
Coconut cake, chekku ..	6·14	23·44	13·00	12·21	42·28	3·3	18·99	81·8
Gingelly cake	11·02	46·30	9·91	4·92	27·85	1·0	38·34	75·0
Cotton-seed cake ..	6·50	22·84	9·15	24·11	37·40	3·1	17·48	59·3
Cotton-seed	4·66	18·02	20·60	25·74	30·98	6·1	11·24	77·0
Rice bran	22·08	10·40	12·90	14·69	39·85	8·5	6·08	43·5
Wheat bran	5·59	15·41	3·45	10·76	64·79	5·4	10·62	51·2
Redgram *dhall* husk ..	5·74	11·75	1·90	38·77	42·68	12	4·23	39·2*
Bengalgram *dhall* husk ..	5·99	5·75	0·91	48·40	38·95	..	..	29·8
Babul pods	5·44	15·77	0·80	12·44	65·52	4·8	10·92	54·1

Percentage composition of the common South Indian feeding stuffs—(Continued)

Name of feed	On a dry basis					Nutritive ratio	Digestible nutrients in 100 lb. of raw material	
	Ash	Crude protein	Fat	Fibre	Carbo-hydrates		Digestible protein	Starch equivalent
E. Grains								
Sorghum	2·20	10·00	4·20	4·00	77·90	9·0	7·04	73·2
Maize	1·50	11·10	4·90	2·50	77·90	8·1	6·83	84·3
Rice, polished	0·90	7·50	0·40	1·70	87·80	12	5·66	84·4
Wheat	2·00	15·60	3·00	2·90	73·40	5·3	10·44	77·6
Horsegram	5·10	24·74	0·96	4·82	64·38	2·2	20·20	65·7
Cow pea	3·65	28·10	0·80	4·35	63·70	2·2	29·10	67·5
Groundnut kernel ..	2·80	29·70	42·30	6·00	12·20	4·4	23·80	141·8

Source : *Bulletin No.* 25 (1952) *of the Indian Council of Agricultural Research, New Delhi, mainly. Items marked with asterisk are from miscellaneous sources, with the digestible protein and starch equivalent worked out with Indian and foreign digestibility coefficients.*

Note; *It may be assumed that dry feeds contain* 10 *per cent. moisture and green feeds* 75 *per cent. moisture, roughly.*

*Average digestibility coefficients of Nutrients in some common feeding stuffs**

Name of feed	Crude protein	Ether extract	Crude fibre	Carbo-hydrates
		Roughages		
Ragi straw	6	41	67	58
Rice straw	..	35	72	53
Bangalore hay ..	2	39	63	50
Bellary hay ..	11	43	60	52
Sorghum hay, prime ..	41	28	60	44
Hariali hay ..	73	51	63	54
Groundnut hay ..	69	..	39	64
Lucerne hay ..	77	30	51	68
Sorghum silage ..	40	47	63	53
Ragi straw silage ..	8	44	69	52
		Green Feeds		
Napier grass ..	62	59	63	65
Guinea grass, young ..	74	47	78	75
Guinea grass, prime ..	58	43	61	52
Sorghum, prime ..	44	44	59	60
Lucerne	80	46	50	72
		Concentrated Feeds		
Cotton-seed ..	69	90	63	59
Groundnut cake ..	90	97	10	51
Gram husk ..	..	85	66	71
Wheat bran ..	77	66	20	84

*Source: *Mis. Bull. No.* 25, 1952, *Indian Council of Agricultural Research New Delhi.*

CHAPTER VIII

FEEDING MATERIALS

The bulk of the feeding material for cattle consists of straws of cereal crops, which are grown in 23·7 million acres occupying about 75 per cent. of the total cultivated area in Madras and Andhra States, *bhusa* of pulse crops occupying nearly 3 million acres and miscellaneous fodder crops occupying 0·5 million acres. Besides the above, concentrated feeds are also given to superior bullocks and milch animals. The important cattle feeds and fodders available in South India are considered below.

Rice straw.—Rice is grown in about 11 million acres in Madras and Andhra States and it is estimated that 14 millions tons of rice straw are produced annually. Rice straw has a low feeding value, though analytical figures indicate that it is as rich as sorghum straw. When milk animals are changed over from sorghum to rice straw feeding, there is an immediate drop in milk yield. The rice straw contains considerable silica, which gives strength and stiffness to the stalk and prevents the crop from lodging, and also certain oxalates, which lower its digestibility.

Sorghum straw.—This is an important fodder for cattle. It is a good feeding material and is conserved carefully by farmers. The cows in sorghum areas are better milkers than in other regions. The best bullocks are produced in sorghum regions. There are two types of sorghums, one having sweet juicy stems and the other having pithy stems. The *Thella jonna* of Bellary and the *Pacha jonna* of Nandyal are examples of the juicy types and they are relished by cattle. The *Thalai virichan cholam* of the central districts is a representative of an extremely pithy type, which is rejected by cattle. The straw is very stout and pithy and is used as fuel. There are also a few pithy types, which are used for feeding animals.

Ragi straw.—*Ragi* is mainly grown in garden lands in Madras and Andhra States. After the earheads are gathered

from crops, the stalks are left standing in the field, to provide green fodder for the farm animals. In course of time, the stalks turn yellow and start drying. The straw is then harvested, dried and kept stacked for feeding cattle in times of scarcity of fodder. The dry straw is coarse, fibrous and of low nutritive value. It is not relished by cattle, though it improves when kept over in the stack for some time, as a result of the fermentation that takes place in the stack. When large areas of *ragi* are grown, the green straw may be ensilaged. The silage has also a low feeding value, but is relished and eaten readily by cattle.

Ragi straw produced in dry lands under rain-fed conditions is a fairly good quality fodder. It is grown as a dry crop in small areas, where rainfall is favourable, as in parts of Salem and Visakhapatnam districts. It is relished by cattle and the peasants conserve it carefully for feeding cattle.

Cumbu.—This crop tillers profusely and provides nutritious green fodder that compares favourably with other green fodders. The crop makes rapid and vigorous growth and is particularly useful in times of scarcity of fodder, when it could be produced in a short time. It is an important cereal of the dry black soil areas, but the dry straw is pithy and poor in quality. It is commonly used for thatching roof, though it is used as cattle feed in times of scarcity of fodder.

Minor millet straws.—*Tenai*, *samai* and *panivaragu* straws are all thin and readily consumed by cattle, with apparent relish. They are of low feeding value in general. *Varagu* and *kudiraivalli* straws are rather coarse and are rarely used for feeding cattle.

Leguminous bhusa.—The leaves and husk of the pods that separate out from the leguminous plants on the threshing floor are carefully gathered and stored for feeding cattle. The thin and pliable stems of the vinous leguminous crops like horsegram and *pillipesara* are also collected from the threshing floor along with the other refuse. All these together go by the name of *bhusa*. *Bhusa* is rich in protein

and is rightly valued as a good feed for cattle. It is carefully conserved and given in small quantities to the more valuable animals. Groundnut haulms have the same value as *bhusa* and they are also dried and used as cattle feed.

Grasses.—These are the natural herbage for cattle. They spring up everywhere, in forests, communal lands, tank bunds, waste lands, etc., and provide good feed during the rainy season. Young grasses are rich in protein. It is on account of this that cattle pick up condition during the rainy season. As the grasses mature, they get fibrous and the total dry matter content and bulk increase, and the protein content and digestibility decrease. Apart from supplying nutrients, they supply carotene, the precursor of vitamin A, which contributes to the health of animals and is hence important.

A survey of the natural pasture grasses indicates that they are generally fairly well supplied with minerals, except in certain localities. Grasses in the West Coast are poor in lime and phosphorus, those in North Salem in calcium and those in parts of Kurnool and Anantapur in phosphorus.

Grass is also cut and given to cattle to supplement the grazing during the rainy season. The growth of grass is never so abundant as to facilitate its conservation as either hay or silage. Hay is made in a small way by Government in Bellary district, to serve as reserve fodder during famine years.

Green fodders.—South India has a monsoon type of rainfall with definite seasons of rainfall and grass growth is limited to these seasons. A number of fodder crops could however be grown for providing green feed for cattle right through the year. Though the value of green feed is well known, green fodders are not generally grown, as the land available for cultivation is limited and the need for growing human food and commercial crops is great.

Grass crops found suitable for cultivation under South Indian conditions are the perennial crops like the *kolakattai* grass, water grass, Guinea grass and Napier grass. All these provide nutritious green fodder, which may be placed respectively in the above order, both from the point of view of

productivity of green matter and nutritive properties. The *kolakattai* grass has a thin stem and is consumed by cattle without any wastage. It is palatable and relished by cattle. Water grass has a slightly thicker but herbaceous stem and the wastage is generally negligible, except when the crop is mature. It is apt to be rejected, when it is cut early in the morning with the dew on. Guinea grass is comparatively coarse, but it is readily eaten by animals. The thicker stems are rejected and there is apt to be some wastage. Napier grass has a hard woody stem, which is not much relished by cattle. This defect is, however, offset by its luxuriant growth and heavy tonnage. It is a suitable fodder, when it is tender, during the early stages of growth.

Sorghum is grown in small plots in the Central districts, for providing green fodder for the mhote bullocks, during the summer months. Mhote work is a heavy strain for the bullocks and they require some green feed for maintaining their condition. This shows that the peasants know the value of green feeds. The limitation of holdings does not, however, permit large areas being set apart for the cultivation of green fodder.

Water hyacinth (*Eichhornia crassipes*) is generally taken to be a serious pest infesting waterways and irrigation sources. The leaves are a valuable green feed. They are collected carefully from the small tanks round about the Tirunelveli town and sold as green fodder. The milkmen claim that the green hyacinth leaves improve and maintain the secretion of milk in buffaloes. It does not appear to be used as fodder elsewhere.

Leguminous fodders.—These are rich in protein, calcium and phosphorus and are extremely valuable as cattle feed. They supply just those ingredients that are deficient in the cereal fodders and are therefore suitable supplementary feed. Leguminous fodders that are specially cultivated are lucerne and sunhemp. Sunhemp is grown as a catch crop in the heavy wetlands of Guntur, Krishna and Godavari districts, with the moisture available in the fields after the harvest of the

rice crop. The sunhemp is cut at the flowering stage, dried and stacked with rice straw in alternate layers, for improving the feeding quality of the latter. Lucerne is a perennial green fodder crop, that can be grown under irrigation. It is grown regularly at most agricultural stations and by a few farmers.

Leguminous green manure crops are allowed to be grazed to a certain extent by cattle in some regions. Leguminous growths are palatable and are apt to be consumed in large quantities, when cattle are allowed to graze them. The time allowed for grazing may have to be regulated to suit the tolerance of individual animals to the feeds concerned. They are apt to set up bloat and tympanitis, leading to mortality in certain cases. The cattle may be given some straw and their stomach partially filled, before they are allowed to graze leguminous growths. *Pillipesara* in the Circars, daincha in Madurai and lab-lab in Tirunelveli districts are some of the green manure crops that are allowed to be grazed by cattle to an extent. The cattle pick up on leguminous grazing and the work bullocks get fit for the heavy and arduous work connected with the preparation of the land for planting rice.

Agathi (*Sesbania grandiflora*) and sometimes *kalyana murungai* (*Erythrina indica*) are grown as standard for betel vine. Where betel vine is extensively cultivated, the loppings of these trees are regularly given to cattle and the concentrated feed is correspondingly reduced. Both are leguminous trees and the leaves are rich in protein. *Agathi* is very much relished by cattle and contains 7 per cent. of protein in the green state and 28 per cent. on a dry basis. Green *agathi* leaves supply as much protein as three-fifths part of cotton-seed or one-sixth part of groundnut cake. That is, one part groundnut cake, 3·715 parts cotton-seed and 6·222 parts of green *agathi* leaves supply the same quantity of protein.

Fodder trees.—The leaves of some trees, such as *nallamada* (*Avicennia officialis*, L.), *chirrathellathiga* (*Derris ulginosa*, Benth.) and *yepi* or *acha* (*Hardwickia binnata*, Roxb.), are used for feeding cattle in times of scarcity of fodder. They are all fairly nutritious. The pods of *karuvel* (*Acacia

arabica) and *velvel* (*A. leucophloea*) are crushed lightly and fed to cattle as concentrates. *Prosopis juliflora* is an exotic leguminous tree that comes up well in South India. It is said that in its original home, a well grown-up tree provides pods for meeting the concentrated feed requirements of three to five horses.

Concentrated feeds.—These may be divided into three groups, depending upon whether they supply mainly proteins, fats or carbohydrates. They are represented by legume seeds, oil seeds and cereal grains respectively and their by-products. The materials supply all the nutrients in general, but are rich in one or two nutrients specifically. For instance, cotton-seed and groundnut cake are rich in protein and supply fair quantities of fat also. Concentrated feeding materials are generally costly and cattle can be maintained cheaply by supplying the nutrients with farm grown produce to an extent. Cows giving up to 20 to 25 lb. of milk daily are maintained on good pastures and lucerne hay in other countries, without recourse to concentrates. The common concentrated feeding materials available in South India are considered below.

Fat and protein suppliers.—Oil seeds as such are seldom used as cattle-feed. The oil is expressed and the residue left behind, called cake, or oilcake is used for feeding cattle. Oilcakes contain 8 to 12 per cent. of fat, depending upon the method of extracting the oil. The protein content ranges widely, from 23 to 54 per cent. depending upon the type of oil seed. The cakes are valued more for their protein than for their fat. They tend to get rancid on storage and mouldy during wet weather. Rancid and mouldy cakes are not suitable for feeding and may be used as manure instead. As the cakes do not keep well in storage, they should be purchased in small quantities as and when required.

Groundnut, gingelly and coconut cakes are commonly used for feeding cattle. Groundnut cake contains 50 to 54 per cent. of protein and 8 to 10 per cent. of fat and is one of the richest feeding materials. It is cheaper than other cakes and is consequently in great use. It tends to produce a soft

butter, which is difficult to gather. Gingelly cake has an inviting flavour and contains 46 per cent. protein and 10 per cent. of fat. It is relished by cattle very much and is used as an appetiser. It is rather costly. It tends to produce butter of medium-hard consistency. Coconut cake is also costly, but is one of the most balanced natural feeds, containing 8 to 13 per cent. of fat and 23 to 25 per cent. of protein. It tends to harden the butter and improve the flavour.

Cotton-seed is commonly used as feed for cattle. It is not classed as an oil seed in South India, though oil is extracted from it in other places. It contains about 20 per cent. of fat and 18 per cent. of protein. It hardens the butter produced and this is of special value in the tropics. It is soaked in water, ground and fed to cows. The liquid portion is sometimes used for feeding calves. The seed is given to work bullocks without crushing, either in a dry or soaked state.

Pulses.—The leguminous grains used as human food are called ' pulses '. They are not given as such to cattle. *Pillipesara* sown for green manure sets pods heavily in certain years and the pods are then collected and used for feeding cattle in Nellore district. Dewgram and horsegram are also given as feed to cattle sometimes, when they are available in the farm in large quantities. Cattle are fed on greengram and Bengalgram also, though rarely.

Dhall husk is the outer coat of the pulse seed, collected during the separation of the cotyledons, known as *dhall*, for use as human food. The husk usually contains varying quantities of cotyledons, which increases its value. Redgram and to a small extent Bengalgram *dhall* husk are available in the market in fair quantities and are valued as good cattle feed. Redgram *dhall* husk contains about 11 per cent. of protein and is valued as a good feed that improves the flavour and quality of the milk in cows.

Cereals are rich in carbohydrates and poor in fat and protein. They are not economic feeds for cattle which produce small quantities of milk. *Ragi* and *cumbu* grains are crushed, made into gruel and fed to calves, when they are

in poor condition. Cereals are producers of energy and they are easily digested by cattle. Maize, oats, barley and to a smaller extent wheat are used for feeding cattle, horses, pigs and poultry in Europe and America.

Rice bran.—This is obtained as a by-product of the rice-milling industry. It is rich in minerals and contains fat and proteins in small amounts. The bran obtained by hand pounding rice is a valuable feeding material. That produced in the power mills is a mixture of bran and fine rice husk. The husk is an inert, indigestible material, which gives bulk to the product and reduces its feeding value and quality. When mill bran is consumed in large quantities by cattle, it tends to set up impaction of the rumen.

CHAPTER IX

FEEDING AND REARING CATTLE

Feeding calves.—Calves have a delicate digestive system and can digest only liquid food. They are given only milk in the first few weeks. In India, they are allowed to suck the teats of cows and have their feed of milk before and after milking. They remain with the cows for 10 to 15 minutes after milking. The calves raised by this natural method of feeding are called ‘suckling calves’. The calves get their feed once in the morning and once in the evening at the time of milking. The interval between feeds is long and the calves develop a keen appetite and are likely to get overfed, if the milk allowed to them is not controlled. But milkmen regulate the quantity of milk allowed to the calves for economic reasons, and the milk allowed does not meet their requirements in full. They are consequently poor in condition. Their growth is checked and this is never completely made up later.

The milk secreted by the cow for the first 3 to 5 days from calving differs from normal milk and is called colostrum. It is rich in protein, mineral salts and vitamin A content. Vitamin A protects the delicate intestines against bacterial infection and immunises the system considerably. The colostrum is also slightly laxative and has a cleansing action on the bowels of the young calf and it should be allowed to have its full feed of colostrum.

The young calves should be kept in a protected pen, provided with an impervious floor. When the calves are kept on earthen floor, a muzzle may be slipped over the mouth, to prevent them from licking the earth. A small tuft of grass may be kept hanging in the pen from the third week onwards. The calves learn to nibble grass from the fourth week and take straw after 8 weeks. When they eat straw, they require some water for drinking, three or four times a day. Calves that have started taking grass may

be given a mid-day feed of gruel. It is made by boiling *ragi* or some other cereal flour with seven parts of water. Two pounds of gruel may be given in the beginning, with a little salt and two ounces of groundnut cake flour strewn over it, at the time of feeding. These may be increased gradually and eight ounces of ragi flour and four ounces of cake given by the end of the third month. More ragi flour is not needed even later. The calves do not require any milk after four months, though under the system of milking in India, the calves are allowed to suck the teats of cows to start the flow of milk.

The scale of feeding that may be adopted for calves of different ages is given below:

Schedule of ration for calves

Age of calves	Milk		Groundnut cake oz.	*Ragi* flour oz.
	morning lb.	evening lb.		
Up to one month ..	4	4	..	..
1 to 2 months ..	3	3	..	..
2 to 3 months ..	2	2	2	4
3 to 4 months ..	1	1	5	6
4 to 6 months ..	..	..	8	8

Note: Ragi flour is mixed with 7 parts of water or skim milk boiled into gruel, salted lightly and fed.

Artificial feeding of calves.—The new born calves are separated from the cows, from birth or three to four days after birth in Western countries. When they are left with the cows, they suck the teats of cows and get the necessary colostrum. They are later separated and not allowed to suck the cows. They are fed regulated quantities of clean fresh milk at body temperature. The cows allow the milk to be drawn by hand or with machines, without the stimulus of sucking by calves. The cows in India appear to be more

temperamental. If they are allowed to be sucked by calves in the beginning, they do not let down the milk subsequently without sucking. If the calf is separated from the cow at the first parturition itself, without allowing her to see the calf, she allows her milk to be drawn without the preliminary sucking.

Calves are weaned at birth in the various dairy countries and fed according to requirements; this is considered to be the most satisfactory method of rearing calves. It has certain advantages, namely (1) the calves are given regulated quantities of milk according to their actual requirements, (2) the cows continue to give milk uninterruptedly, whether the calf is alive or not, (3) the udder of the cow is not fouled by the calf and milk produced is therefore cleaner and (4) the productive capacity of cows can be determined accurately. This may, however, have one serious objection. If cows, trained to let down milk without the calf sucking the teats, are sent for grazing, milk may then be tapped by unauthorised persons.

The calf that is reared by hand feeding has to be first taught how to drink milk. A finger is dipped in colostrum and put into the mouth of the calf and it starts sucking the finger. The finger is then immersed in colostrum held in a clean shallow basin and the calf's mouth is directed to the finger. The calf draws colostrum, while sucking the finger. The natural instinct of the calf, to suck the teats of the cow, is utilised in training the calf to take the milk from the basin. Calves drink colostrum from the basin in three or four days, without any further assistance.

A calf requires one-eighths to one-tenths of its own weight of milk as feed daily, when milk is the sole feed, and 6 to 8 lb. of milk a day meet its requirements. The schedule of rations given above is a guide for feeding weaned calves and suckling calves in a general way, though the milk allowed from the cow to the calf has also to be taken into account.

Growing calves.—Calves are very delicate at birth, but get hardy in about six months. They grow very rapidly

thereafter and mature early, when they are liberally fed. Liberal feeding is economical in the long run. Vigorous heifer calves come to maturity in about 15 months and may be served, if their growth is satisfactory. Sexual maturity does not synchronise with physical maturity, and growth may continue even after conception and parturition. Heifers do not usually come to heat till they are 2½ to 3 years of age under village conditions in India, where feeding is not satisfactory. Bull calves display sexual activity in about 12 months, but are not necessarily fertile at this early age. They may, however, be kept separated from cows and heifer calves and allowed to serve sparingly, once a fortnight, after they are 21 months of age. Occasional service does not affect the growth of the young bulls and their breeding life. Frequent service at an early age retards growth and leads to premature loss of fertility.

Pregnant cows.—Cows in calf require to be fed well, to keep them in good condition and to maintain the proper growth of the fœtus. The fœtus makes rapid growth during the last two months of gestation and the cows require liberal feeding during this period. Good feeding during this period and building up condition is referred to as 'steaming-up'. If the cows are in proper condition, without being too fat or too run-down, they are able to stand the strain of parturition and of the subsequent lactation extremely well. The condition of the cow at the time of parturition has a considerable influence on the production of milk. A cow in proper condition starts the lactation with a good flow of milk and maintains it throughout.

A cow in advanced pregnancy has to be kept separated from the rest of the herd, to avoid accidental injury being caused by other animals. She may be looked after by the same attendant and groomed by him, so as to make her get used to handling and to avoid causing trouble when milking is commenced. Gently massaging the udder twice or thrice a day for a few days before parturition makes the first calvers gentle and quiet at the time of milking. They do not also

resent the assistance of the accustomed attendants at calving time, if necessary. After the cows get accustomed to being milked regularly, they tolerate change of milkmen, without any sepcial difficulty.

Cows may be fed easily digestible tender grass for a few days before and after calving, to facilitate the proper movement of the bowels at the time of delivery. The animal system is subject to a severe strain during calving and raw rice is often given to newly calved animals, for providing them with energy from an easily digestible material. The feeding of concentrates may commence about a week after calving.

The calving stall should be capacious and provided with impervious floor, that can be easily cleaned. A layer of straw provides a comfortable bedding for the animals. This is particularly necessary during cold weather.

Some cows are persistent milkers and continue to give milk till the next calving time. They should, however, be dried off at least two months before calving. Lactation is a big strain on the animal system and if the cow does not get sufficient rest for recouping, the production of milk in the next lactation may be seriously affected. Drying off persistent milkers is not always easy. If milking is stopped, the secretion of milk may cease with certain animals and there may be no trouble. With others, the secretion of milk would continue, milk would collect in the udder and lead to udder troubles. Feeding concentrates should then be stopped and if necessary, the dry roughage feed also should be reduced. It may be necessary to milk such animals once a day to start with and prevent the collection of milk in the udder setting up inflammation. The interval between milkings may be gradually increased, till the secretion of milk stops completely. Each animal has to be dealt with according to her nature. One can learn only by actual experience of management how each individual cow should be dealt with. After the cow is dried off, she may be fed iberally to build up her condition. Concentrates are given to animals due to calve at 3 to 5 lb. a day. During this period

of rest, the fœtus makes rapid growth and the cow recoups her system and comes to normal. The udder tissues that had been active during the previous lactation also get recouped.

Milch cows.—The production of milk is a natural function of the cow, that commences at the time of parturition. The capacity to produce milk and the persistency of lactation are no doubt inherited. It is also influenced to a large extent by the health and condition of the cow at the time of commencement and during the lactation, and by the care bestowed on its maintenance. When cows are overfed, they tend to put on fat at the expense of the milk. When feeding is meagre, they adjust themselves to the level of feeding and the amount of milk produced gets correspondingly reduced. In any case, the quality of the milk is not much affected by the level of feeding. Where particular ingredients are deficient in the feed, the animal draws on the body reserves and maintains the various ingredients in milk at the normal level, though it loses condition consequently. Under-feeding as well as over-feeding reduces the production of milk. A cow with a good constitution and capacity produces milk satisfactorily, when the feeding is at the correct level and tends to have a loose appearance, indicating that all her energies are directed towards milk production. The ration that has to be given is dependent on the quantity of milk produced, as indicated already.

If cows are fed properly and kept in good condition, their milk production does not interfere with the reproductive functions. Oestrus first appears about a month after calving and at intervals of 21 to 25 days thereafter, provided the cow is maintained in proper condition. Sufficient time must be given for recovering from the strain of calving, before she is served again. It is best to serve cows three months after calving, when they would continue to be in milk for a further period of seven months and have two months of rest before the next calving. If service is postponed, the dry period and the cost of maintenance are increased, and the cost of production of milk is raised proportionately.

Cows do not come to heat for a long time after calving, under village conditions in India, due largely to the low level of nutrition. The body calcium and phosphorus are brought down to a low level during the lactation and till that level is raised, œstrus does not appear and is not regular even afterwards. This can be remedied only by adequate feeding and proper maintenance.

Cows are in an excited state during œstrus and develop sexual desires. They are restless and bellow occasionally. This is the most prominent symptom that draws the attention of the cowherd. The bellowing attracts the attention of bulls. When the cows are let loose, they jump about and mount over other animals. There is also a slight discharge of mucus from the genitals. The œstrus lasts for a period of 8 to 24 hours. If it is not watched and the animal served in time, she does not conceive. The next œstrus may be expected after an interval of 3 to 4 weeks normally and after an indefinite interval in under-nourished and unhealthy cows. A single service does not always ensure conception and some cows may require two or three services. A cow in normal health may generally be taken to have conceived, if œstrus does not appear within a month of serving.

Cows are kept contented by proper feeding, housing and gentle handling and this is reflected in the production of milk. When attendants are annoyed at the time of milking, feeding and cleaning the stall, they handle the cows roughly and are harsh sometimes, which affects the temperamental cows and tells on their milk yield. Cows prefer the attendants and milkmen to whom they are accustomed. Feeding just before milking is likely to improve their mood and they do not give trouble at the time of milking. The daily concentrated ration may be divided into two portions and given in the morning and evening, before milking time. Some cows give milk without trouble, when they are fed on concentrates at the time of milking. It may be necessary to secure the hind legs of cows and the tail with a piece of rope at the time of milking, to prevent them from kicking and to

avoid contamination of milk by dust and dung from the switch of the tail. When the cow lies down, the udder and teats are in contact with dung and urine on the floor and require to be cleaned with water before milking. The excess moisture over the udder is removed with a clean dry towel, to prevent the wash water dripping into the milk through the teats.

Breeding bulls.—These are vigorous and strong animals, which are often aggressive. They can, however, be kept under control with the use of nose strings and nose rings. Twisted cotton rope about half an inch in diameter is passed through a hole punched in the nasal septum and the two ends of the rope are gathered behind the horns and held together with a knot. Leading ropes from the nose strings are used for controlling and guiding the animals. The nose ring or the bull dog clamp is a ring about 2 inches in diameter, made with $\frac{1}{4}$ inch copper rod. The ring is inserted through the nasal septum and the two ends are held together by a screw.

Bulls in active service require liberal feeding. They may be kept in separate stalls and taken to the cow at the time of service. When they are let out with the cows at grazing time, they serve the cows in heat repeatedly and exhaust the cows and themselves. The bull may be left in an enclosed paddock with the cow in heat, for service. When the bull is heavy and the cow is small in size, it is an advantage to have service cribs. The cow is secured in a narrow alley 27 inches wide. The low walls of the alley are built in brick and cement and the bull rests its front legs on the top of the wall during service and the cow does not bear the weight of the bull. Bulls that are allowed to serve without restraint have a short breeding life of six or seven years only and get unfit for service when they are about nine years of age. When they are kept separated from the cows and the frequency of service is regulated, they are fit for service up to 12 years of age or more. Very virile bulls have been noted to be capable of service, even up to 17 years.

Young bulls that are well grown may be allowed to serve, even when they are 21 months old. The number of services should, however, be restricted to 25 in the first year, 50 in the second year and about 100 per year from the third year of their breeding life. As the bulls are fed liberally, they are apt to put on fat and be slow at service, if they are not given adequate exercise. Regular farm work, like carting and light ploughing, for half a day provides sufficient exercise and maintains their efficiency at service.

Bullocks.—These are used for farm work and are provided with feed according to the schedule of rations furnished. It must, however, be mentioned that the schedule is only a general guide and that individual requirements may vary. In large farms, where a number of bullocks are kept, the several animals would receive individual attention, if they are allotted specifically to the different labourers, who can take them out for work in the fields and attend to their feeding and management. The labourers would be in close touch with the bullocks allotted to them, know their individual peculiarities and characteristics and regulate their management suitably. The work given to the animals may be changed and varied, so that all animals in the farm may have light and heavy work equally. Continuous heavy work is likely to affect the longevity and working life of animals. Puddling wet lands and mhoting are heavy work. Ploughing dry and garden lands is medium work; road work and ploughing with small indigenous ploughs, harrowing and intercultivating are light work.

The hooves of bullocks are apt to wear off when they are used regularly for road work and require to be protected with iron shoes. Animals on road work may require shoeing once a month. Those working in the field require renewal of shoes once in two or three months. Animals with soft hooves require shoeing more frequently than those with hard feet.

CHAPTER X

MANAGEMENT OF CATTLE

Management of cattle.—This is a general term, denoting all operations connected with the maintenance of cattle. It includes feeding, housing, providing drinking water, grooming and washing animals, providing exercise, treating sick animals and training young stock. The feeding of cattle has already been dealt with.

Housing.—Cattle are kept in sheds or stalls of various types, which are designed to give adequate protection to the animals against the weather. The sun is rather severe in the tropics and cattle are affected when they are exposed to the hot midday sun, particularly during summer. Cattle may commonly be seen stopping grazing during noon and seeking the protection of trees in the grazing grounds. If the animals are exposed to rain and cold winds, considerable body energy is taken up for maintaining the body temperature and this leads to lowered health and predisposition to diseases.

Most peasants in South India put up cattle sheds of a temporary nature. The space required for the shed is marked and surrounded on three sides with mud walls and the fourth side is left open to serve as entrance for animals. Manger is provided close to the wall opposite to the entrance. A few vertical pegs driven into the ground in a line parallel to the wall and some bamboo slats tied horizontally to the pegs form the manger for holding the feed. It is about two feet wide, 1½ feet high, and runs the whole length of the shed. The earthen floor of the shed gets wet and soft by the urine voided by the animals. The urine soaked earth is scraped once in a way and dry earth is spread for maintaining the level of the floor. The animals lie down on the moist earth and get soiled with urine, dung and earth. Dirt sticks to their body more or less permanently. This is an unsatisfactory method of keeping cattle and collecting the manure produced by them.

The peasant's cattle shed requires to be improved. This may be done in several ways. Keeping cattle in loose boxes is a satisfactory method. Pits 3 feet deep, 10 feet wide and of varying length, allowing 5 feet per animal are dug and the floor and sides are cement plastered and made impermeable. Steps are provided on one side for the animals to get in and also a roof for protection against sun and rain. Straw is kept in movable mangers for feed.

A layer of waste straw, dry leaves and organic wastes collecting in the farm is spread over the floor. The dung is spread over the pit daily and is not removed. The loose box serves as the cattle stall and the manure pit. The dry material used as bedding is called litter. It absorbs the urine voided by animals and the surplus moisture in the dung, and the stall is maintained in a tidy condition. Waste straw and litter are provided periodically, when the old litter gets moistened and does not absorb urine readily. The floor rises gradually with the accumulation of manure and the pit is filled up in the course of about 6 months. The manure is carted straight to the field, excepting the dry top layer, which is kept aside and spread over the floor after the removal of the decomposed manure.

The loose box is a convenient system for keeping work cattle and collecting manure. It requires the least space as it combines the cattle stall and the manure pit. The entire quantity of urine and dung voided is collected, without much labour. The cattle keep clean and their health is not affected adversely. It is, however, not suitable for cows. It is constructed at little cost and is not beyond the means of middle class peasants.

The loose earth cattle shed is also satisfactory and does not require any initial investment like the loose box stall. The floor is made of loose tank silt to a depth of about 9 inches. The silt moistened with cattle urine is collected along with dung every day and stored in the manure pit. The floor is levelled after removing the urine soaked silt. Fresh silt is added periodically and the floor is maintained

at the original level. All the urine voided by animals is conserved and the quality of the manure is consequently improved.

Masonry cattle sheds provided with stone or cement floor and urine channels are constructed by the well-to-do farmers. Both the shed and the animals are kept clean easily. Masonry sheds are beyond the capacity of the ordinary peasant. But masonry sheds with impervious floor are needed for cows, so that clean milk of satisfactory quality may be produced.

Size of cattle sheds.—The width of cattle sheds may be about 10 feet, which gives sufficient space for the animals to stand confortably. When the animals are tied side by side, a space of about five feet may be allowed for each animal. The manger may be two feet wide, one foot six inches high and run the entire length of the shed, The length of the manger available for each animal is five feet and it can hold sufficient straw for one night. The manger may instead be built close to the wall with brick and mortar. Galvanized iron troughs also can be provided. Portable bamboo troughs of a box type are in use in the Coimbatore district. These can be shifted from place to place, when the animals are penned in the field. Standard troughs intended for a pair of animals are 9 to 10 feet long, $2\frac{1}{4}$ feet high and $1\frac{3}{4}$ feet wide. The sides are made of bamboos flattened out by hammering. The box is kept suspended close to the ground in a bamboo framework.

Drinking water.—Cattle require large quantities of clean water for drinking. The feed of cattle is made up mostly of dry fodder and water is required for moistening and digesting it. The water needed is about four times that of the dry feed. In addition to it, cows require four parts of water for every part of milk secreted by them. Thus a medium sized cow consuming 11 lb. of dry fodder and producing 5 lb. of milk requires $4 \times (11 + 5)$ or 64 lb. of water. The water consumed by the cow is excreted through urine, dung, perspiration and milk.

Cattle are supplied with drinking water twice or thrice a day. This restricts the quantity of water that they consume. When they have free access, they consume more water than when it is supplied at stated intervals. Water should therefore be kept in suitable containers near the animals.

Grooming and washing animals.—Grooming consists of rubbing the animals with wisps of straw. This may be done twice a day for cows, before they are milked, to remove the loose hairs about the abdominal and udder regions, which may contaminate the milk. Grooming stimulates the skin and the circulation of the blood is improved, leading to the maintenance of skin health. Animals groomed daily have a healthy and glossy coat.

The hairs about the flanks and the udder of cows may be clipped close, to reduce mud and dung sticking to the udder region. It keeps the cows in a clean condition and promotes the cleanliness of the milk produced.

Even though cattle are groomed daily, they get soiled with dung and urine, while lying down. The parts of the body that are in contact with the floor are discoloured and the animals require washing at least once a week. The soiled patches on the body may be rubbed over with coir mittens, for removing the discolouration. Buffaloes require wallowing in water twice a day, to keep their system cool.

Exercise.—Bulls and bullocks have sufficient exercise while doing farm work. The calves jump about and get sufficient exercise when they are grazed in paddocks. If there are not any grazing facilities, they may be let into open courtyards, that are fenced all round. Calves kept tied in stalls get ungainly in appearance and sluggish at work later at the adult stage. Cows that are sent out for grazing have some exercise, while moving about and grazing. They have been used successfully for farm work in some agricultural stations in North India. They work efficiently, but are not suitable for heavy work. Light farm work does not apparently affect their breeding and milking efficiency. Those that are used for farm work have to be fed liberally, to pro-

vide sufficient nutrition and energy for the production of milk and the output of power. Heavy and strenuous work like puddling and mhoting are obviously not suitable for cows. Heavy work is likely to affect the secretion of milk and the efficiency of breeding. Further, the cow is a delicate animal already undergoing a heavy strain in producing calves and milk. She may break down if subjected to strenuous work.

Care of sick animals.—Sickness develops in animals gradually, in general. Sick animals are not normal, they do not feed properly, their coat gets bristled, the muzzle gets dry and they have a dull, staring and depressed look. These symptoms do not escape the notice of careful and observant stockmen. Animals showing symptoms of ill-health have to be separated from the rest of the herd and kept in special isolation wards, away from healthy animals. They may be provided with a thin bedding of straw and made comfortable. The feed should consist of easily digestible tender grass and gruel made with cereal grains. Plenty of water has to be provided for drinking. When the sickness is serious veterinary assistance should be provided.

The segregation of sick animals is a simple precaution that pays handsome dividends. If animals contract contagious diseases, their early segregation may prevent the contagion from spreading and affecting the other animals in the herd.

Training.—The training of young bullocks requires considerable skill, understanding of the animal nature and patience on the part of the stockmen. Mistakes committed during the training period may spoil the animals for life. Correct training is therefore of special importance. When the young animal is first put to work, the neck is tender and is tickled by the yoke. It should therefore be gently accustomed to the feel of the yoke and light carting work on good roads may be given, pairing it with a trained bullock. Light pain develops about the neck, where the skin is tender. This is shown in an unmistakeable manner by its reluctance to proceed with the work after a time. This is a warning signal

and it should not be strained further. The work may be gradually increased, as the neck skin gets tough. If the animal is worked for a long time in the beginning itself, intense pain develops over the tender neck, it is unable to proceed with the work and it lies down. There is immediate relief and the pain in the neck lessens considerably. This starts the vicious habit of lying down, when the animal is disinclined for work and if left unchecked the habit persists till the end of the animal's life.

When young animals are put to work for a long time, before the neck skin gets tough, there is abrasion of the skin and when the work is continued, wounds develop and the neck is injured permanently. Though the wound may get healed, the neck becomes a weak spot and remains tender always. Neck sores and yoke galls develop with this as the nucleus, when the animals are strained at work in later life.

CHAPTER XI

OTHER LIVESTOCK

Sheep.—The total number of sheep in Madras and Andhra States together during 1951 was 15 millions. There were about one million sheep or more in the districts of Anantapur, Nellore, South Arcot, Salem, Coimbatore, Tirunelveli and Ramanathapuram. Humid districts like the Nilgiris and the west coast maintained a few thousands only. The number of sheep in each of the other districts ranged from one to seven lakhs.

Sheep are maintained in flocks of 25 to 100 by shepherds, who make their living by them. The sheep are their sole capital and they do not have any cultivable land or other means of subsistence. They are not associated with farming as in other countries and sheep raising is not a farm enterprise; they are not farmers in any sense, but merely shepherds. A few goats are also kept along with the flock of sheep. The sheep are grazed on waste lands, tank bunds, the sides of roads and harvested fields. Such natural and free pasturage is available in regions where rainfall is scanty and scrub jungle and waste lands abound. It is in such regions only, that large numbers of sheep are maintained. The sheep population is in proportion to the free natural grazing available.

Hairy types of sheep.—The sheep raised in India may be divided into two types, the hairy and the wooled types. The hairy sheep are found distributed all over South India. They are predominantly red in colour or brown, with an admixture of black. The ewes are hornless and the rams have twisted horns growing sideways. They are maintained for providing mutton and manure. They are taken out for grazing during the day and penned in fallow fields for manuring during the night. Sheep penning is usually done for the more valuable crops and is paid at Rs. 1½ to 2 for 100 sheep penned for a night.

The common red sheep.—The hairy sheep seen all over South India are red or brown and are called the 'red hairy sheep'. They are of non-descript types, with live-weight ranging from 40 to 60 lb. each. The mutton is of average quality.

The Nellore sheep.—These are the biggest sheep in South India. The rams weigh up to 150 lb. and the ewes 100 lb. each. The prevailing colour is white, black or brown in various combinations. The mutton is of good quality.

The wooled types of sheep.—These are confined to the comparatively cooler regions like Coimbatore, North Salem and Bellary. Their prevailing colour is white with black face. Irregular patches of black and brown of various sizes are found over the body. Large patches of colour detract the value of the wool and are disadvantageous. White wool can be coloured suitably and has a greater value and demand than coloured wool in the market. Sheep with pure white fleece are rare; they are of a delicate constitution and are unthrifty. They do not grow well under the rigorous climatic conditions prevailing in South India. The wool produced here is coarse and suitable only for making rough carpets and blankets. The wool clip is also low, being 1 to 1·5 lb. per head annually on the average. The wool is clipped in the month of March.

The Bellary sheep.—These are of the wooled type. The prevailing colours are black, white with black face and white with patches of black or brown over the body. A few whites are occasionally seen. The wool is rather coarse and suitable for making rough carpets. The annual wool yield is 1·5 to 2 lb. per head for ewes and 4 to 7 lb. for rams. The ewes weigh 60 to 70 lb. and the rams about 120 lb. each.

The Coimbatore sheep.—These are similar to the Bellary sheep in all respects, but are smaller in size and are believed to have a dash of Persian blood. The ewes weigh 50 to 60 lb. and the rams 90 lb. each. The annual wool yield is 1 to 1·5 lb. per head for ewes and 2 to 4 lb. for rams.

Clipping wool.—The wool fibres have a number of serrations about the surface, which hold and lock them together

during spinning. They are 4 to 6 inches in length, with diameter ranging from 1/1,500ths to 1/500ths of an inch. Fine wool has more serrations than coarse wool. On the other hand, hairs have no serrations on the surface and cannot therefore be held together by spinning. They are hence unsuitable for making yarn. Clippings contain wool, hair and fat. The wool fat is a cutaneous secretion, which is about 15 per cent. of the weight of the fleece with sheep exposed to the weather. The fine fleece of the Merino sheep and some other varieties of sheep contain often more than 50 per cent. of fat. When the sheep are washed before clipping, the wool is freed of extraneous dirt, which may account for 25 to 30 per cent. of the weight of the uncleaned fleece. Washing facilitates the clipping and subsequent processing of wool and clean wool is obtained. Being devoid of foreign matter, it is less in weight, but it fetches a better price and washing sheep before clipping is no loss.

The wool obtained from the different parts of the body are of varying quality and it pays to clip and keep the different sorts separately. Three grades, called 'prima', 'seconds' and 'thirds' are recognised. Prima is from the neck and back, seconds from the tail and legs, and thirds from the breast and belly. Graded wool fetches a better price than unsorted wool, on the whole. White wool gets a better price than coloured wool, and these may be kept and marketed separately. White wool mixed with coloured wool gets the same price as coloured wool.

Feeding sheep.—The mating season for sheep in South India is March–April and they lamb in September–October, with a gestation period of 5 months. They are not given any special feeding during the period and they do not breed regularly. If the ewes are given concentrated feed for a few weeks at the mating season, they would come to heat in time, their breeding would be regular and the lamb crop would be satisfactory. The concentrates may be made up with equal parts of groundnut cake and rice bran, and half a pound of the mixture would meet the daily requirements of the ewe.

A good ram serves 40 to 50 ewes during the mating season, which is a big strain on the system. Rams require special feeding during the mating season and $\frac{3}{4}$ lb. per head of a mixture of groundnut cake and rice bran would meet their daily requirements. Sheep are not given any concentrates in South India and they subsist on natural pasturage, which is not always satisfactory. There is good grazing after the rains, but very little grass is available in summer. The sheep do not grow well; ewes weigh 50 to 60 lb. and rams 75 to 90 lb. each.

Improvement of sheep.—The sheep in Madras are of poor quality in general and no attempt is made to improve them. Animals that are hardy and are able to pick up feed by themselves survive; they get along even in times of scarcity. Better animals can be raised by breeding, but the improvement will not show itself till feeding and grazing conditions are bettered. The existing sheep have adjusted themselves to the poor and uncertain grazing, the climate and the other environmental conditions that prevail and the care and attention that the shepherds are able to afford. Merino sheep have been used for crossing sporadically by individuals. The cross-bred sheep are better animals, but do not have the constitution to adapt themselves to the prevailing rough and scanty grazing and the enthusiasm for cross-breeding has not therefore been sustained. There is no doubt that sheep could be improved considerably by suitable breeding methods, but that alone will not help, as suitable and better feeding cannot be afforded by their keepers.

Goats.—A few goats only are kept by individuals and not flocks like sheep. The total goat population in the composite Madras and Andhra States was 3 millions in 1951. Goats are small animals that are maintained cheaply and that produce milk and meat economically. They are maintained on grass and shrubs growing on uncultivated land, loppings from the trees on the sides of roads and on plants and shrubs growing about live fences. They feed on all kinds of plants and are a menace to young trees and vege-

table patches in cities. Allowing goats to browse freely without restraint and lopping roadside trees for providing feed are unsociable practices that deserve severe condemnation.

Milch goats.—Goats are maintained in South India for their meat and skin, though small quantities of milk are given by individual animals. Special milch goats of a mixed type, derived from Sindhi, Cutch, Surat and Arab breeds introduced by traders at different times are maintained for the production of milk in the West Coast districts, where under the prevailing heavy rainfall conditions, cows do not thrive. Goats, on the other hand, do well and the rainfall provides good vegetation for browsing. They give 2 to 5 lb. of milk a day and are maintained at a low cost. All these favour the maintenance of goats in the West Coast. The milk is used chiefly for making tea and is seldom used for direct consumption as fluid milk. It has a raw odour, which is not relished. It is not therefore used in regions where cows can be kept for the production of milk. Further, the he-goats have an objectionable odour about them, which is very offensive.

Jack leaves are the main roughage for goats in the West Coast. The milch animals are given in addition ½ to 1 lb. of concentrates made up of equal parts of groundnut cake, rice bran and coconut cake. Ground blackgram and Bengalgram are given as extra feed to particularly heavy milkers.

Goats kid once in 8 to 9 months and 1 to 3 kids are born each time. They are allowed to suck the mother's milk and get about ¾ lb. daily. They are weaned at two months and fed on jack leaves, supplemented by oilcakes and ground Bengalgram. Male kids are sold when they are six months old and the female kids are reared for the production of milk.

Pigs.—Pigs are commonly raised in European countries for the production of pork and bacon. It is a subsidiary farm enterprise, particularly of the dairy farmers. Skim milk and whey are by-products in the manufacture of butter and cheese, which are utilised profitably, when pig raising is also done side by side. Pig raising complements the dairy

industry. Roots, grains and miscellaneous farm produce are the main feed for pigs. They are the most economic flesh producers; one pound of pork is produced from 4 to 5 lb. of dry feed, while steers require 12 to 16 lb. of feed for the production of 1 lb. of beef.

There were one million pigs in the Madras and Andhra States together during 1951. They are not, however, maintained here as farm animals and the consumption of pork is also against Hindu sentiment.

Pigs are maintained by a poor class of people, who consume pork. They are kept under very insanitary conditions and left to fend for themselves; they feed on fæcal matter, household wastes and anything that becomes accessible to them. They have a long snout, arched back, flattened ribs and long legs. They take two years to mature and the flesh is of poor quality. Of the various breeds of pigs introduced by the English settlers at different times, the Berkshire pigs have done well. They have short thick snouts, straight backs, rounded barrel and short legs. They mature in 10 to 12 months and weigh 150 lb. each on the average.

Indigenous pigs can be graded up with Berkshire boars. But the cross-bred stock cannot thrive under the conditions in which the indigenous pigs live now. So long as proper feeding cannot be done, there is no point in trying to grade up the indigenous pigs.

Care and management.—Pigs are despised animals here, mostly because of the conditions under which they are kept. They learn clean habits easily under suitable environment. A cement floor is a primary need, if pigs are to be kept clean. Wallowing in water keeps them healthy and they relish it like buffaloes.

Breeding sows should be capable of producing large litters and the number of teats of sows is an indication of the size of the litter they could produce. Sows with less than 12 teats produce small litters and are not profitable to breed from. Berkshire pigs farrow twice a year and produce about 10 piglings each time, under proper feeding and management.

The boars should be kept separated from the sows, except at mating time. Both boars and sows are fit for breeding at 8 to 10 months and have a breeding life of 3 to 4 years. Boars not required for stud should be castrated and fattened for pork.

Feeding pigs.—Pigs have omnivorous feeding habits and thrive on a mixed diet. They can be given grass, vegetable peel and rejects, banana peel, jack fruit nests, jack leaves, cashew apples, mango seed kernels, tamarind seeds, palmyra nuts, etc. They should be allowed to forage freely in fields, for getting the necessary exercise. They help to uproot rhizomes, bulbs and nuts of persistent grasses and weeds, expose grubs and pick up groundnuts left behind after harvesting.

Pigs are quick growing animals, which require liberal feeding with concentrates, right through life, as they are either growing, fattening, or breeding; irregular and insufficient feeding retards growth and tells on their performance. Concentrated feed may be made up with oilcakes, rice bran and crushed sorghum or ragi grain. In addition, fish meal up to four ounces may be given daily; larger quantities taint the flesh. Fatty foods may also be supplied in moderation; a generous supply of fat in the feed promotes softness and oiliness in the pig's fat. Grains tend to harden the fat. Pulses help the formation of firm flesh and fat. The concentrates may be given in a sloppy condition twice a day normally and thrice a day during the last two months of fattening. The grains may be crushed and mixed with other feeds.

The forage and concentrates do not supply sufficient minerals for the pigs and they require to be supplemented with half an ounce of mineral mixture daily; this helps to maintain the growth and to build up strong bones.

The sows produce sufficient milk normally for maintaining the piglings for the first three weeks or so. When the sows do not secrete sufficient milk, the piglings may be given cow's milk at body temperature. They may be weaned at 7 to 8 weeks and kept growing on cake and other concentrates. Skim milk may be given, if available. They require liberal feeding, as growth lost by underfeeding is never made up later.

PART II

DAIRYING

CHAPTER XII

IMPORTANCE OF DAIRYING

Origin of dairying.—Dairy is an all-embracing term used for the industry connected with the production, processing and distribution of milk and milk products. It also includes the premises and the farm area, where milk is produced, the arable land where fooder is grown, the yard where cows are kept and calves are reared, the milking shed, and the building where milk is processed and the various milk products are made. The use of the term creamery is restricted to the premises, where milk is separated and butter is made from cream.

The origin and development of the dairy industry is shrouded in antiquity and it is not definitely known how milking of animals commenced and how milk came to be used as human food. The cow is held in great veneration in India, almost to the point of worship. The development of such an attitude of mind is an indication of the great value placed by people on the cow as the producer of milk. It may be presumed that man domesticated the small animals like the sheep and goats first and took flocks of these animals along with him in his early nomadic life. These were able to pick up their feed and did not require any supplementary feeding. The bigger sized cattle, ferocious in their natural habitat required to be provided with feeding material in addition to what they managed to get by grazing and may have been domesticated later, after man settled down to a life of farming. Buffaloes are ferocious in a wild state and may have been domesticated, after the use of the cow as a producer of milk was firmly established. Milking the animals, using milk for human consumption and converting it to curds and butter appear to have been known from very early times. A knowledge of the possible uses of the domesticated animals may have preceded their capture, taming and domestication.

The domestic cattle are valued for their beef, milk and draught qualities. India is not much concerned with beef, but is vitally interested in milk and draught. Milk and beef are incompatible and excellence in both cannot be combined in one and the same animal. The draught and milk qualities do not appear to be so incompatible and it has been possible to promote in the same animal a fair degree of excellence in both.

Milk production statistics.—India has the largest cattle population in the world, 188 millions out of a world total of 690 millions.[26] Next come U.S.S.R. and U.S.A. with 65 and 58 millions respectively. The importance and value of the cattle wealth to India are obvious. The following statement gives the production and consumption of milk in some important countries.

World's annual production of milk

Country	Total production of milk in lakhs of maunds, of 82 2/7 lb.	Cow population in lakhs	Annual milk production per cow in pounds	Daily consumption of milk per head of population in ounces*
Denmark (1942) ..	834·39	13·91	5,291	40
New Zealand (1945)	1,169·41	17·00	5,680	56
U.S.A. (1946) ..	15,197·43	388·66	3,218	35
Britain (1945) ..	2,236·48	24·03	7,658	39
Finland (1945) ..	431·60	11·22	3,165	63
India (1945) ..	4,682·15	606·73	413 (Cow)	5·4
			1,101 (Buffalo)	
Madras ..	278·6	50·96	450 (Cow)	4·2
	186·1	29·43	800 (Buffalo)	
E. Punjab ..	188·65	10·75	1,445 (Cow)	16·8
	391·89	13·9	2,320 (Buffalo)	
Uttar Pradesh ..	417·12	54·93	625 (Cow)	7·16
	687·69	45·44	1,240 (Buffalo)	
Grand Total ..	52,307·23			

Source: *Report on the Marketing of Milk in the Indian Union*, 1950.

* Wright, N. C., *Report on the Development of the Cattle and Dairy Industries of India*, 1937.

Indian Union is the largest milk-producing country in the world, barring the United States of America, but with the lowest production per cow and the lowest consumption of milk per head of human population. The Finnish people consume 56 ounces of milk per head daily and the corresponding Indian figure is 5·4 ounces. The consumption per head of population varies from State to State with the lowest consumption of 1·23 and 1·34 ounces of milk in Assam and Travancore respectively and the highest consumption of 16·8 ounces in East Punjab.

The average daily consumption of milk in the Indian Union is 5·4 ounces per head of population. In a diet survey conducted in Madras, 31 out of 44 families taken at random did not use milk in any form. The average consumption of milk in the rest of the families was less than 3 ounces of fluid milk, supplemented with ghee and buttermilk, the equivalent of 4 ounces of milk. The daily average consumption of milk per head in all the 44 families was less than 2 ounces.

Dietary requirements of milk.—Aykroyd, W. R., computed in 1937 that a daily consumption of 15 ounces of milk was necessary for meeting the daily nutritional requirements of adult human beings in India. The Nutrition Advisory Committee of the Indian Research Fund Association raised this figure to 20 ounces, in 1944. The European standard daily requirement is estimated at 35 ounces of milk and possibly the difference in climate is responsible for the difference between the two standards. Milk contains valuable proteins necessary for supplementing a predominantly vegetarian diet. It is a protective food capable of making up the deficiency of vitamins and minerals in a cereal diet. It promotes growth in the early stages of development of both animals and human beings. From a consideration of all these aspects, it is clear that the production and consumption of milk in India should be increased at least three times and raised from the existing level of 5·4 ounces of daily consumption per head to 16 ounces.

Milk intake and income levels.—When the monthly income of the family is over Rs. 1,000 a month, the *per capita* consumption of milk reaches 30 ounces a day. With the income below Rs. 100, the consumption is less than 3 ounces a day. The obvious remedy is to increase the production of milk and reduce its cost of production, so as to make it cheap enough to be within the purchasing power of the lower income groups. It is seen, however, that the cost of milk has increased four-fold in the last decade.

Yield and cost of production of milk.—The average production of milk per animal in India is about 750 lb. per lactation, with an average daily yield of $3\frac{1}{2}$ lb. on the assumption that the average lactation is 200 days. As is to be expected, the cost of producing milk at this level is high. The cost of milk is negatively correlated to the level of production. Wright, N. C.[26] has illustrated this in the form of a graph with American data. The cost of production of milk is taken as 100, at the level of 400 lb. of milk per lactation, the equivalent of a daily milk yield of 2 lb., on an assumption of 200 days of lactation. The relative cost of milk derived from Wright's graph for the different levels of milk production is given below:

Level of daily milk yield in lb.	Cost of production of a pound of milk, with 100 as the cost per pound at the level of 2 lb. of milk a day
2	100
$3\frac{1}{2}$	73 (existing level of production)
4	65
6	$47\frac{1}{2}$
8	$37\frac{1}{2}$
10	31
12	27
14	$22\frac{1}{2}$
16	20
18	$17\frac{1}{2}$
20	15

There is a fall in the cost of production of milk, as the yield increases, steeply up to 10 lb. a day and gently thereafter. If the average production of milk could be stepped up to 10 lb. a day from the present level of $3\frac{1}{2}$ lb., the cost index would be reduced from 73 to 31, with a fall of about 57·5 per cent. in the cost of production of milk. The objective for the present may therefore be the improvement of the daily average yield of milk from $3\frac{1}{2}$ to 10 lb., by improved breeding, feeding and management.

Utilisation of milk in India.—A large part of the milk produced in the Indian Union is used for the production of ghee and secondly for consumption directly as liquid milk. Small quantities are used for the manufacture of various milk products as shown below:

Name of product	Percentage on total production in Indian Union	Annual consumption of milk in lakhs of maunds					
		India	Madras	Bombay	East Punjab	Uttar Pradesh	West Bengal
Ghee ..	43·3	2,085	299·99	113·54	179·50	359·28	52·06
Fluid milk ..	36·2	1,741	184·61	58·78	174·11	439·87	107·58
Curds ..	9·1	438	86·54	23·26	47·87	95·14	3·31
Table butter	6·3	302	3·46	12·05	179·50	44·77	0·99
Khoa ..	4·1	200	1·15	2·54	2·39	152·22	1·32
Ice-cream ..	0·4	20	0·86	1·27	5·98	11·19	..
Cream ..	0·6	30	0·29	..	8·98	16·79	..

Source: *Report on the Marketing of Milk in the Indian Union*, 1950, 196.

Of the milk produced, 36·2 per cent. is consumed on the average as fluid milk and 43·3 per cent. is used for the production of ghee. Butter milk obtained as a by-product in the manufacture of ghee is fully utilised for human consumption. Though 10 per cent. of the total milk is used for making khoa and table butter, 75 per cent. of it is concentrated in East Punjab and Uttar Pradesh, the two large milk producing areas.

The demand for European dairy products is rather limited and is met to an extent by imports from other producing countries. The quantities of the various milk products so imported during 1945–46 into the Indian Union and their equivalent of fluid milk are furnished below:

Name of product	Import in cwt.	Equivalent fluid milk in lakhs of maunds
Dairy butter	139	0·03
Cheese	8,760	1·22
Condensed milk, etc. ..	79,687	2·76
Milk foods	17,569	1·99
Total ..	106,155	6·00

Source: *Report on the Marketing of Milk in the Indian Union*, 1950, 38.

A total quantity of Western dairy products, to the equivalent of 6 lakhs maunds of milk or 0·12 per cent. of the total annual milk production in India, was imported during 1945–46 and is negligible.

CHAPTER XIII

THE SECRETION OF MILK AND ITS PROPERTIES

Lactation.—Milk is the fluid secreted by the mammary gland of the female mammalia, which is intended for the sustenance of the new-born. The secretion of milk commences a little before parturition and it continues for a certain period, that is, till the young animal is able to fend for itself. This is called the lactation period. Different classes of animals and individuals of even the same species have varying lactation periods and it may range from 8 to 18 months with cows and buffaloes, with most animals having a lactation period of about 10 months.

Milk as food.—Milk is intended by nature for the nourishment of young animals and it may therefore be expected to contain all the nutrients required for the growth and sustenance of the young of the species, in just the right proportions. The feeding, care and management of cows influence the quantity of milk produced, but not its composition to any marked extent normally. Milk is in a form that could be digested by the delicate stomach of the young animals. It is an excellent diet for growing children, as well as invalid human beings. It promotes growth better than any other single substance. Nutrition experts hold that milk should be an essential part of the food for human beings and that about 20 ounces a day would meet the normal requirements of the human system. Though this is not disputed, it is possible that this point is being over-emphasised, as nature could not have intended that an adult animal should depend upon another for milk, which is primarily intended by nature to be an infant food. But there is no doubt that milk is a good auxiliary food for human beings, adults as well as babies, that makes up for many of the deficiencies in a purely vegetarian food.

The production of milk.—The udder of the cow is a glandular organ that secretes milk. It is divided into two

halves, the right and the left, by a vertical membrane. Each half is made up of two glands, one in front extending towards the navel and the other behind extending up to the perineum. The four glands constituting what are called quarters function independently, so that if one or more gets diseased, the secretion of milk is decreased correspondingly, but not stopped from others. The hind quarters are 50 per cent. more capacious than the fore quarters and secrete 60 per cent. of the milk. Each quarter has a tubular exit through the teats, which is used for extracting the milk. The teats are roughly cylindrical and tubular. The tubular passage is the teat canal, which has two sphincter muscles, one near the exit and the other at the junction of the teat and the milk cistern above it. The milk cistern is an oblong cavity that serves as the reservoir for milk. It has a capacity of 8 to 16 ounces. A number of milk ducts empty their contents into the milk cistern. The milk ducts branch and rebranch several times and each final branch ends in what is called an alveolus. The alveoli are hollow glands with a small narrow cavity, which open into the the capillary milk ducts. The cells lining these cavities are the milk secreting cells. The udder tissue is made up of a large number of gland lobules, with each lobule containing many alveoli (bunched together like grapes), muscles, nerves, veins, arteries and connective tissue. The fine capillaries feed the alveoli. The udder is soft, pliable and spongy. It is fully distended before milking due to the collection of milk and is in a collapsed condition after milking. Poor milkers have considerable fatty and connective tissues in the udder, which has a low capacity for holding milk and does not callapse after milking.

The secretion of milk.—The secretion of milk is a continuous process that goes on in the alveoli. The milk is elaborated in the epithelial cells and when they get engorged with milk, they burst and eject tiny droplets of milk into the alveolar cavity. The burst cells get immediately repaired and the secretion of milk continues. How exactly milk is formed from the blood is not known. The milk passes on

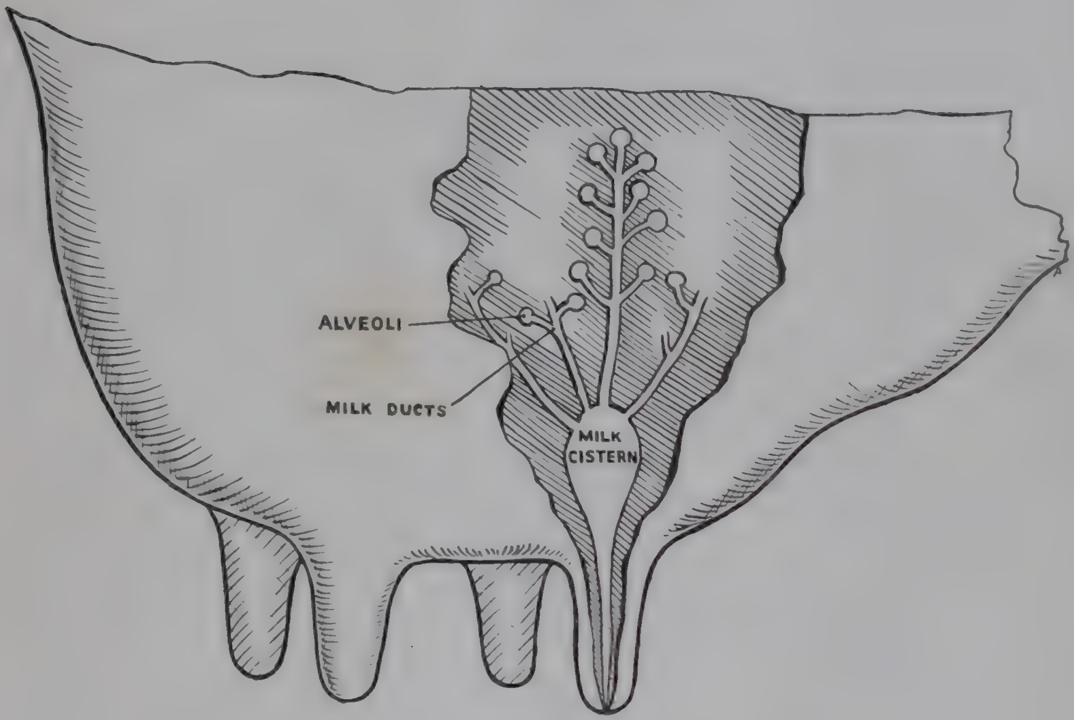

FIG. 6. A diagrammatic sectional view of the udder

from the fine capillary branches to the main duct and finally to the milk cistern. When the alveolar cavity, the branch milk duct, the main milk ducts and the milk cistern get filled with milk, pressure is developed inside the udder and further secretion of milk does not take place, till the milk is sucked by the calf or withdrawn by physical manipulation and the pressure inside the udder is reduced.

The entire quantity of milk withdrawn at each milking is present in the udder at the time milking is commenced. This is opposed to the earlier view that udder contained only a small quantity of milk at the commencement of milking and that most of the milk was actually secreted during milking. This was presumably based on the fact that the milk drawn at each milking was more than what the milk cisterns could hold. Milk is held not only in the milk cistern, but also in the main milk ducts and the profusely branched smaller ducts, which permeate the entire udder tissue.

The let-down of milk.—When the calf sucks the teats of the cow or when milking is done, the pressure applied mechanically relaxes the sphincter muscles of the teats and the milk held in the milk cistern and the bigger ducts is drawn through the teat openings. The milk held in the branch milk ducts and the alveoli cannot be extracted by physical manipulation. This is, however, facilitated by the cow letting down the milk held here and passing it to the main milk ducts under nervous reflex action stimulated by certain hormones. When the calf sucks the teats and butts against the udder, the necessary stimulus is given to the nerves and the harmone, called ' oxytoccin ' is released, into the blood-stream by the pituitary gland situated at the base of the brain. The letting-down of the milk commences within a minute of the release of the hormone into the blood-stream. The hormone gets destroyed in the course of 6 or 7 minutes and the cow is thereafter not capable of letting down the milk from the branch ducts to the main ducts, till fresh stimulus is given and oxytoccin is again released into the blood-stream. In Western countries, the calf is not allowed to suck the milk from the

cow, but is fed with milk that has already been drawn from the cow. The stimulus necessary for the release of oxytoccin is provided by the presence of milkmen, the clanging of milk pails during handling, the tethering of the cows in the milking shed and similar associations experienced by cows in the milking shed. The milkmen clean the udder with a warm towel dipped in warm water at about 120° F. and massage the udder. This gives the final stimulus, almost similar to that provided by the suckling calf, oxytoccin is released and the milk is let down. Since the hormone is dissipated in the blood in the course of 6 to 7 minutes, the milking has to be done rapidly, so that the entire quantity of milk in the udder may be withdrawn. Otherwise, a certain amount of milk is left behind in the udder and stimulus for the secretion of fresh milk in the udder is reduced to that extent. This naturally affects the milk secreting capacity of the cow and the milk flow is gradually reduced in course of time and the cow does not give the maximum quantity of milk she is capable of producing in the lactation. This does not apply to cows in India, where the calves suck the teats of cows after milking and extract the entire quantity of milk held in the udder.

In the case of cows, which do not release sufficient quantities of oxytoccin or where the milking is done slowly, the entire quantity of milk in the udder is not extracted at one milking. When the calves are allowed to suck the teats, after milking, there is release of hormone again and there is a second instalment of let-down of milk, and milking may be done a second time. This is not uncommon in this country. The necessity for the second milking will not arise, if the milkmen are quick at milking. Quick milking stimulates the nerves connected with the secretion, and let-down of milk, the nervous tone and the lactation are maintained satisfactorily, to the full term and the inherent capacity of the cow.

Factors affecting the secretion of milk.—Cows are maintained, fed properly, housed carefully and their health and welfare looked after, so that they may in return produce as

much milk as possible. From this point of view, the cow may be compared to a machine; she produces milk from out of the feed provided. The greater the milk produced out of a certain quantity of feed, the greater is the efficiency of the cow and this is influenced by a number of factors. Some of these are inherent in the cow and some are extraneous like the feed given, the care bestowed in maintaining her, the environment provided, etc., and these may be considered serially.

Individuality.—The capacity of the cow to produce milk is primarily dependent on her inheritance. Animals born of good milk strains of parents produce large quantities of milk. Poor parents give rise to poor milking progeny. Certain breeds are milk breeds, which produce reasonably good quantities of milk. The beef and draught breeds are comparatively poor milkers. Apart from the breed, there is the influence of the immediate parents on the productive capacity of the cows. In addition to heredity, the individuality of the cow is a potent factor determining its productive capacity. Cows born of the same parents have the same heredity, but are not equally efficient in producing milk and this is due to the difference in the individuality or the individual make-up of the animals. Though two sister cows have the same heredity, their inheritances are not identical. The genes responsible for the several characters, derived from the two parents, are assembled differently at the time of mating and this finally influences the productive capacity of the offspring. This is referred to as 'individuality' in the cow, and this is not under the control of the breeder.

Apart from the inheritance, the constitution of the animal also influences the secretion of milk. The capacity of the cow to digest food and convert it to milk is important in raising the efficiency of secretion. A vigorous circulatory system contributes to the efficiency of digestion. The size of the animal has also a bearing on the secretion of milk. The larger the size of the cow within a breed, the greater is its efficiency in producing milk. In general, a larger part

of the food is utilised for production of milk and for work by the big animals than by the small ones.

The age of the cow and the stage of lactation play a part in the secretion of milk. A cow in this country may be expected to be at peak production of milk during the fourth and fifth lactation, which may be about 1·2 times the production during the first lactation. There is a gradual decline in the production of milk from the fifth lactation onwards. The production of milk at the eigth lactation may be 1·1 times the production at the first lactation. Most cows may not normally have more than 8 lactations.

There are variations in the daily production of milk within the lactation itself. The production in the second month is about 7 per cent. more than in the first month. There is a further small rise of 1 per cent. during the third month and a decline from the fourth month onwards by about 5 to 6 per cent. per month and the production in the tenth month may be about 50 per cent. of the first month's production. The cows may dry off thereafter.

Feeding.—The milch cow requires to be fed adequately to maintain the proper secretion of milk. Feed is utilised by the cow for the maintenance of the body, the carrying-out of the various life functions, the production of milk and the sustenance and growth of the fœtus, when she is in calf. The cow's requirements of feed are more than those of other classes of animals, as feed is required by her specially for the growth of the fœtus and the production of milk. Though adequate feeding is necessary, over-liberal feeding may adversely affect the secretion of milk. Cows tend to put on fat on excessive feeding, with the digested feed diverted from milk production to the production of body fat. The milk yield declines consequently. When the feeding is restricted, cows draw on their body reserves for the materials required for the elaboration of milk. If this condition persists, the milk yields decline gradually and the cows lose condition. The composition of milk, however, is not much affected by under-or over-feeding.

Environment and maintenance.—The housing conditions provided for the cow and the care and attention bestowed on her maintenance influence the secretion of milk markedly. These may be discussed under the following heads.

(*a*) *Handling and temper.*—Cows respond to kind treatment by the attendants and this induces contentment and a placid temper in the animals. These influence the secretion of milk and have a value that could not be determined and expressed in terms of particular units. When milk is drawn by the same individual or those familiar with the cows, the secretion of milk is maintained at the normal level. Cows take time to adjust themselves to new milkmen and there is a fall in milk yield during this period of adjustment.

(*b*) *Milking.*—The manner of milking affects the secretion of milk. Slow milking tends to reduce the yields, as stated already. Pulling the teats roughly while milking irritates the cows and the secretion of milk is adversely affected. Leaving milk in the udder after milking has been noted to depress milk yield, in Western countries. This is not likely to influence the milk yields in India, where the calves are allowed to suck the teats after milking and to extract the milk completely from the udder.

(*c*) *Shelter.*—Roomy and comfortable sheds are required for milch animals, to protect them from the hot sun, the cold winds and the rain. When the animals are exposed to the cold winds and the rain, a part of the food is utilised for warming up the animal system and maintaining the body temperature and the energy used for this purpose is unnecessarily wasted. Such a waste is less common in the tropics than in temperate or cold regions. On the other hand, the hot tropical sun enervates the cow and her over-all efficiency, including milk production, is reduced.

(*d*) *Exercise.*—Moderate exercise is beneficial and keeps up the tone of the animal system, resulting in satisfactory performance. The energy so used by animals is more than compensated by the immense benefit derived by them. It has even been shown in some of the Government farms in

North India that milking animals could be used for light farm work like shallow ploughing, carting, etc., so long as the concentrated feed given is increased suitably for supplying the energy needed both for the production of milk and for work.

The properties of milk.—Milk is a white opaque liquid, with a specific gravity ranging between 1·028 and 1·032 with the majority of samples, with the extremes at 1·018 and 1·037. The mean specific gravity of cow's milk is 1·030 and that of buffalo's milk 1·031. The freezing point is $-0 \cdot 5455°$ C. with cow's milk and $-0 \cdot 5426°$ C. with buffalo's milk. The freezing point of fresh milk is its most constant quality and this is used for detecting adulteration. The depression of the freezing point from 0° C. may range from 0·542° to 0·546° C. When water is added to milk, the freezing point is raised. As the milk is kept over and gets acidic, the salts in casein get into solution and depress the freezing point. The boiling point of milk is 212·5° F. Milk is about 1·6 times as viscous as water. Rise of temperature reduces the viscosity of milk. While separating cream from milk, the temperature of milk is raised to 90° F., in temperate countries to reduce the viscosity and thus aid the separation of cream. This is not necessary in the tropics, where the prevailing temperature is near 90° F.

Milk is partly an emulsion of the fats present, partly a solution of substances like lactose (milk sugar), albumin, globulin and mineral salts and partly a collodial suspension of casein. It abounds in calcium, phosphorus, proteins, fat, lactose and vitamins; large numbers of leucocytes or white blood corpuscles and epithelial cells derived from the udder are also present. The leucocytes, epithelial cells and casein give opacity and whiteness to milk.

Fresh milk is lightly acidic with a pH of about 6·5. The acidity may range from 0·12 to 0·16 per cent., represented as lactic acid. The acidity of milk increases on keeping. Fresh milk drawn from the cow contains 6 to 10 per cent. of its volume of gases, chiefly nitrogen, oxygen and carbon dioxide. The nitrogen and oxygen are absorbed during milk-

ing, while carbon dioxide is absorbed when the milk is in the udder. The gases escape on keeping and there is a corresponding shrinkage in the volume of the milk.

Milk coagulates on the addition of acids or rennet, due to the coagulation of the casein in milk. Lactic acid bacilli (also other bacilli) multiply rapidly in milk, producing lactic acid from lactose and the milk curdles on the acidity reaching 0·65 per cent., corresponding to a pH of 4·5. The curdling of milk is referred to as ripening or souring.

Composition of milk.—The composition of milk varies from species to species, breed to breed and from animal to animal in the same breed. Milk is made up of five major constituents, namely proteins, fat, lactose, ash and water. These are important nutrients, which have specific functions in the nutrition of the young animal. The nutrients in the milk of different animals are suitable for the normal growth of the young ones concerned. The analysis of milk is therefore a rough indication of the requirements of nutrients by the young animal for development, till it is weaned. Besides the above, vitamins are also present.

Proteins.—These are a group of complex nitrogenous compounds of great physiological and nutritional significance, as a large part of the body substances is elaborated from them. There are three proteins in milk, namely casein, lactalbumin and lactoglobulin, with a proportional range of 90 to 92 per cent., 7 to 9 per cent. and about 1 per cent. respectively. There are also small amounts of several non-protein nitrogenous compounds in milk.

Casein.—This is a pure white, ashless, tasteless, odourless and non-crystalline solid substance, held in colloidal suspension in milk. It is a phospho-protein and occurs as a calcium salt, called calcium caseinate. It is practically insoluble in water, but readily soluble in alkaline solutions and this property is made use of in the manufacture of casein glues, largely used in the plywood industry.

Common salt disperses the casein particles so much, that they are not visible under the microscope. Casein is

coagulated and precipitated by the addition of acids or the development of acidity during the fermentation of milk. A part of the calcium of the calcium caseinate combines with the acid and releases casein, which gets precipitated.

Casein is also coagulated by the enzyme rennin present in rennet and this is made use of in the manufacture of cheese.

Casein is not coagulated by heat like the other milk proteins. It behaves as a plastic and is used extensively in the plastic industry. It is also used for the production of certain textile fibres, which resemble wool.

Casein contains almost all the known essential amino acids and is therefore physiologically more valuable than other proteins.

Lactalbumin.—This differs from blood albumin, though both have the same amino acid make-up. It is synthesised in the alveoli in the udder and not simply transferred from the blood to the milk. It coagulates readily, but gradually as the temperature of milk is raised. There is very little coagulation, if any, at the temperature of pasteuriastion of milk (140° to 145° F.). It coagulates completely, when milk is boiled and forms a sort of skin on the surface, enclosing with it a small amount of fat. The rise of fat along with the albumin is facilitated by the reduction in the viscosity of milk consequent on the rise of temperature. Albumin is not coagulated by acid or rennin.

Lactalbumin is soluble in water and is held as a solution in the milk serum and forms part of the whey, when milk is curdled by acids or rennin.

Lactoglobulin.—This is similar to the globulins of the blood serum. It is held as a collodial solution in milk and gets coagulated at a temperature of 130° F. It is only a minor ingredient in normal milk, being not more than 0·2 per cent. It is present in very large quantities in colostrum, to the extent of 6 to 10 per cent. It is of high physiological value. Agglutinin and various antibodies present in it protect the delicate intestines of the new-born calf from bacterial attack,

till resistance is built up in the system. Lactoglobulin therefore is of great importance.

Milk-fat.—Milk-fat in common with other fats is a mixture of triglycerides of acids of the aliphatic series. The fatty acids associated with milk-fat are the butyric, caproic, capryllic, capric, lauric, myristic, stearic, oleic and linoleic acids. Small quantities of other acids also may be present. All of them are saturated fatty acids, excepting oleic and lanoleic acids. Steam volatile, water soluble lower fatty acids like butyric, caproic, capryllic, capric, etc., are characteristic constituents of milk-fat, present in appreciable amounts. The proportion of the various fatty acids present in milk-fat varies with the season and the feeds supplied to the animals and this influences the aroma, flavour, texture and taste of the butter and ghee produced.

Feeding cows with oilcakes like groundnut cake rich in oleic acid increases the oleic acid content of the milk-fat and induces softness in butter. Coconut cake with a high lauric and myristic acid content hardens the butter. Feeding green fodder tends to induce softness in butter and that arriving in the market after the onset of the rainy season is soft, consequent on the natural grazing that becomes available for cattle. As summer advances and grazing gets scarce, cows are maintained on dry fodder and the butter produced tends to get harder. Feeding on dry fodder and cereal grains hardens the milk-fat.

The Reichert-Meissel value.—The flavour and digestibility of butter and ghee depend on the lower fatty acids present in milk-fat in abundance. Milk-fat differs from vegetable fats in containing notable amounts of the lower volatile fatty acids. The lower fatty acids are water soluble and steam volatile and their content is expressed by what is called Reichert-Meissel or R.M. value in numbers. The R.M. value varies with the season and the feed given to milch animals. It is lowered by feeding with cotton-seed and the Agmark standard has fixed an R.M. value of 24 for ghee produced in areas, where cotton-seed is given to cows in fair

quantities. Cotton-seed is liberally used as cattle feed in Kathiawar and the ghee in this region has an R.M. value of 20, the lowest in India. Good grazing raises the R.M. value. The R.M. value of ghee produced in Madras ranges from 24 to 32.

Consistency of butter.—The consistency of butter is liable to vary widely due to variations in the extent of the unsaturated oleic and lanoleic acids present, which have low melting points. As the oleic and lanoleic acid content increases, the proportion of saturated acids is reduced, the melting point is lowered and the butter produced is soft. The hardness of butter increases with rise in the proportion of the saturated fatty acids. The texture of hard butter is granular and that of soft butter is pasty, like that of vaseline.

Cholesterol.—An important constituent of milk-fat is cholesterol, a monohydric alcohol. Its isomer, phytosterol, is found in vegetable fats. The presence of phytosterol in vegetable fats and its absence in animal fats is utilised for detecting the adulteration of milk-fat with vegetable oils. The adulteration of ghee with *vanaspathi* or hydrogenated vegetable oil has become so common that the sale of pure *vanaspathi*, without the addition of a certain amount of deodorised gingelly oil, is prohibited by law. The phytosterol in gingelly oil can be detected easily in the ghee adulterated with *vanaspathi*. This restriction is not effective in preventing such adulteration being practised widely and commonly. It is very difficult to purchase ghee that has not got *vanaspathi* mixed with it. If the colouring of *vanaspathi* is insisted on instead, it will easily enable the customers to detect the adulteration of ghee with *vanaspathi* and protect their interests.

The detection of phytosterol is based on the difference in the melting points of the phyto and cholesteryl acetates. Phytosteryl acetate melts at 129° C. and cholesteryl acetate at 113° C. Any increase in the melting point of the acetate over 113° C. is proportional to the quantity of phytosterol present and the quantity of vegetable oils used for adultera tion. This is called the phytosterol acetate or P.A. test.

The Baudoin test.—When equal quantities of (1) concentrated hydrochloric acid with a few white sugar crystals dissolved in it and (2) a suspected sample of ghee are mixed and shaken well, the mixture turns pink, if *vanaspathi* is present in the ghee sample.

Lactose.—Lactose or milk sugar is present in milk to the extent of about 5 per cent. It is not as sweet as sucrose and it imparts only a faint sweet taste to milk. It has a low solubility and small hard crystals of lactose are formed when milk is condensed or frozen. This gives a gritty feel to such products and handicaps the manufacture of condensed milk and ice-cream. Lactose gets charred when the temperature of milk is raised to 150° F. and this imparts a caramelised odour to milk.

When milk is kept over, the bacteria present in it use the lactose and produce lactic acid. Butyric and carbonic acids are also produced along with it in small amounts. A part of the lactic acid dissolves the calcium in the casein and forms calcium lactate. The casein gets flocculated on loss of calcium and the milk curdles, when the acidity developed amounts to about 0·65 per cent. and takes the appearance of a solid mass.

Lactose is largely used in the manufacture of invalid foods. The increase in the lactose content of cow's milk by the addition of lactose makes it extremely suitable for infant feeding. Lactose is also used in the manufacture of confectionary and as a vehicle and binder in medicinal pellets.

Ash or mineral matter.—The ash in milk contains the mineral ingredients required for the growth of young animals in the proportion required. Cow's milk contains about 0·75 per cent. ash and buffalo's milk about 0·80. The mineral matter is partly in solution and partly in suspension associated with calcium, phosphorus and casein. It is composed of phosphates of calcium, potassium and magnesium, chlorides of sodium and citrates of sodium, potassium, magnesium and calcium. Of the several minerals, calcium and phosphorus are very important, constituting more than half of the total

mineral content. They promote the growth of bones in the young animal. The mineral matter present influences the osmotic pressure of milk and depresses the freezing point. The citrates in milk impart the characteristic flavour to butter by the production of diacetyl.

Vitamins.—Milk is a rich source of vitamins and almost all the vitamins necessary for the maintenance and growth of young animals are present in milk. Vitamin A and its precursors, carotene and cryptoxanthine, are present in milk, associated with the fat. The yellow colour of milk-fat is indicative of its carotene content. Buffalo's milk-fat is white in colour, but it contains vitamin A in sufficient quantities and is nearly as valubale a protective food as cow's milk-fat. Cow's milk contains 180 international units of vitamin A per 100 gm. and buffalo's milk contains 162 units.[2] Vitamin A and its precursors are not affected by heating the milk.

Almost all the B vitamins, like thiamine, riboflavine, niacin, pantothenic acid, pyridine, biotine, choline, folic acid and also the new vitamin B_{12}, are present in milk. Ruminants synthesise them in the rumen, with the help of the bacteria that are present there and pass them on to milk. Besides, there are still other unknown growth factors in milk, like the whey factor, etc. Of these, riboflavin or vitamin B_2 is the most abundant and is present in the greenish fluorescent pigment in milk, originally known as 'lacto chrome' and now as 'lacto flavin'. Riboflavin is only slightly soluble in water and is destroyed by heat in an alkaline medium, though it is heat stable in an acid medium. Bright sunlight and pasteurisation can destroy a large part of this vitamin.

Vitamin C or ascorbic acid, the anti-scurvey vitamin, is present in milk in reasonable quantities. It is unstable and is destroyed during the processing of milk, particularly in the presence of air and sunlight. Traces of copper derived from milk utensils accelerate the destruction of vitamin C.

Milk and butter are also good sources for the supply of vitamin D, the calcifying vitamin. This vitamin is associated with the fat in milk. Bones are not readily formed, even

when calcium and phosphorus are present in the feed in sufficient quantities, if vitamin D is lacking and it is hence called anti-rachitic vitamin. Only a very small part of the vitamin in the feed is passed on to milk. Considering the importance of this vitamin in the nutrition of children, milk is reinforced with vitamin D in several ways. It may be added to milk directly in the form of concentrates of high potency, prepared from the unsaponifiable fraction of fish liver oils or irradiated ergosterol. The vitamin D potency can also be increased by irradiation with ultra-violet rays and milk so treated is called 'irradiated milk'.

Vitamin E is present in the fatty fraction of the milk and is called the anti-sterility vitamin. When there is not sufficient vitamin E in the system, there is reproductive failure in rats, but this does not seem to affect the reproduction of other animals. Vitamin E is present in milk in sufficient quantities.

Variations in the composition of milk.—There are wide variations in the composition of milk of the different classes of animals. Such variations are seen even in the milks commonly used for human consumption. The milk of the European cow (*Bos taurus*), the Indian cow (*B. indicus*) and the water buffalo or the buffalo (*B. bubalis*) as it is more commonly called, are largely used for human consumption. They are all animals of the same genus, but of different species. There is considerable difference in the composition of the milk of even these closely related animals, as is seen in the following statement. The analysis of the Indian cow's milk and buffalo's milk are of whole herds, with the samples spread over three months (for Table see next page).

The various factors affecting the composition of milk under Indian conditions have not been studied in detail. It, however, appears probable that the factors affecting the composition of milk in Western countries may operate in the same manner here also and they may be considered briefly. Wide variations are noted in the fat content than in the other constituents of milk. These variations have been studied in detail.

Composition of Cow's and Bufialo's Milk

Ingredients	European cow (1)	Indian cow (2)	Indian buffalo (2)
Water	87·32	85·28	81·76
Total solids	12·68	14·72	18·26
Solids-not-fat	8·93	9·05	10·15
Fat	3·75	5·67	8·11
Protein	3·40	3·69	4·33
Lactose	4·75	4·69	5·00
Ash	0·75	0·76	0·82

Source: (1) Davies, W. L., *The Chemistry of Milk*, Chapman and Hall, London, 1936, pp. 7.

(2) *Mem. Dept. Agric. India* (*Chemical Series*), **2**, pp. 8 and 199.

Factors Affecting the Composition of Milk

1. *Breed effects.*—There is considerable difference between breed and breed in the fat content of milk. The fat content is a character that is inherited through the breed and through the parental stock. The normal fat content of the milk of some of the Indian cattle breeds is given below:

Breed	Fat percentage	Solids-not-fat percentage
Ongole	5·05	..
Sindhi	4·84	8·42
Gir	4·54	9·15
Tharparkar	4·60	9·63
Hariana	4·60	9·68
Murrah buffalo	7·30	9·25

Source: *Report on the Marketing of Milk in the Indian Union*, 1950, 124.

2. *Individual variations.*—Apart from the differences between breed and breed, there are variations in the fat content of milk from animal to animal within the same breed as seen below:

Name of animal		Specific gravity at 15° C.	Fat percentage	Solids-not-fat percentage
		Sindhi cows		
Kalyanwaty	..	1·0322	5·69	9·03
Hirka ..	..	1·0324	4·81	8·46
Dukki ..	..	1·0293	4·66	8·16
		Murrah buffaloes		
Chandrika ..	..	1·0334	7·05	9·49
Dhan konwar	..	1·0334	7·38	9·64
Maharajin ..	..	1·0340	6·57	9·41

Source: *Report on the Marketing of Milk in the Indian Union*, 1950, 126.

3. *Length of period preceding milking.*—Milk drawn after a short interval is richer in fat than that drawn after a long interval.

4. *Time of milking.*—Evening milk is richer in fat and poorer in solids-not-fat than morning milk, as seen below:

Breed		Fat per cent.		Solids-not-fat per cent.	
		Morning	Evening	Morning	Evening
Tharparkar, 50 cows	..	4·4	4·8	9·14	8·92
Hariana, 40 cows ..	..	4·4	4·8	9·2	8·96

Source: *Report on the Marketing of Milk in the Indian Union*, 1950, 128.

5. *Portion of milk tested.*—First drawn milk or fore-milk is very poor and the last drawn milk or strippings is very rich in fat content. The milkmen take the cow from door to door in Madras and draw a little milk from each teat for their customers serially. The fat content of samples of milk received by each customer from the same Ongole cow during the course of a day illustrates the variations, as seen below:

Customer No.	Particulars of milk	Quantity in lb.	Fat per cent.	Remarks
1	First drawn milk	2	1·8	morning
2	Second ,, ,, ...	3	4·9	,,
3	Third ,, ,, ...	2	9·0	,,
	Composite average	..	5·2	..
4	First drawn milk	3	4·1	evening
5	Second ,, ,, ...	2	8·8	,,
	Composite average	..	6·0	,,
	Average for the day	..	5·5	..

Source: Littlewood, R. W., *Livestock of Southern India*, 1936, 174.

Customer No. 1 gets the poorest milk with a low fat content and customer No. 3 gets the richest milk for the same price. Sample No. 3 is five times as rich as sample No. 1. If a child gets its feed of milk from sample No. 1 in the morning and from sample No. 5 in the evening, its feed will have 1·8 per cent. of fat in the morning and 8·8 per cent. in the evening. This would naturally affect the digestion and the delicate stomach of the child. Supplying milk to customers from the same cow, drawing the milk in instalments at different houses is common in Madras City. If the milkmen draw milk from each quarter completely for each customer in turn, the inequality in the fat content of milk will be reduced to a large extent.

6. *Stage of lactation.*—The quantity of milk produced by the cow declines with advance in lactation. As the milk yield falls, there is increase in the fat and solids-not-fat contents of milk. While the fat content increases with advancing lactation, the size of the fat particles gets reduced. When the cream produced is exclusively from cows in advanced lactation, churning butter takes more time.

7. *Age of the cow.*—As the cow advances in age, there is a progressive fall in the fat content of milk and the total quantity of milk produced.

8. *Feed.*—As long as a balanced feed is given, there is not much variation in the fat content of milk. With underfeeding, the total amount of fat got from the cow decreases as the production of milk falls down, though the percentage of fat in milk may increase slightly. Cows losing condition through underfeeding do not come to high production easily and without considerable expenditure of time and money.

Five grade cows in Perdue University were underfed in one lactation and liberally in the next one and the relative production figures given below show how the level of feeding can affect the production of fat and milk, and the profitableness of keeping cows.

Particulars	1. Poor feed	2. Rich feed	Difference 2 *minus* 1
Milk produced	5,063 lb.	8,663 lb.	3,600 lb.
Fat produced	203 lb.	317 lb.	114 lb.
Fat percentage	4·01	3·66	..
Value of milk	$ 121·36	$ 213·59	$ 92·23
Cost of feed	$ 47·94	76·55	$ 28·61
Margin of profit	$ 77·64	$ 137·04	$ 59·40
Profit as percentage of the cost of the feed	161·9	192·0	..

Source: *Hoard's Dairyman*, Nov. 25, 1941.

There does not appear to be any relation between the quantity of fat fed and the fat content of milk. The carbohydrates and fat in the feed appear to be interconvertible. The deficiency of the one is made up by an excess of the other. But the kind of fat in the feed affects the composition of the fat produced. Cotton-seed, coconut cake and grains produce firm butter, containing more of palmitin and stearin, while groundnut cake tends to give soft butter with a greater proportion of fats with low melting point.

The food value of milk.—Milk is nature's food for the young animals and it is the most complete food known,

containing all the nutrients required, in the proper proportion. It is easily digested and is very palatable. It can be consumed directly by itself or combined with various types of food. It is agreeable with all types and varieties of food. It is thus an ideal type of food in all ways.

Milk proteins.—These have a high biological value. Proteins break up into various amino acids during digestion and the value of a protein to the animal system is dependent on the number, proportion, quantity and the kind of necessary amino acids being present in it and also its digestibility. Milk proteins have all the essential amino acids required by the animal system and the only other protein that has about an equal value is the egg protein. Milk and egg proteins are 90 to 95 per cent. digestible, while other proteins are digestible to the extent of 70 to 85 per cent. only. Milk proteins are hence extremely suitable as human food.

Milk-fat.—This is not any better than other fats as far as the production of energy is concerned. But milk-fat abounds in vitamins A and D, which are lacking in other fats. Further, it has a great appeal to the palate, on account of its distinctive flavour and taste, which other fats lack.

Lactose.—This is the sugar present in milk. Lactose gives a subdued sweetness, which does not cloy the palate as other sugars. It provides as much energy as others.

Ash.—The mineral part of milk is rich in calcium and phosphorus, required for building up bones in the young animals. Calcium and phosphorus are present in milk in both organic and inorganic forms and are readily assimilated. The other salts required for the animal system are also present in milk ash.

Vitamins.—All the vitamins necessary for the maintenance and growth of young animals are present in milk in sufficient quantities. Vitamins are protective substances that build up resistance to diseases in the animal system and make it function efficiently.

Enzymes in milk.—Enzymes are organic catalysts, which by association bring about chemical changes in other substances, without themselves undergoing any change. They are of a protein nature and several vitamins form part of the co-enzymes. Enzymes produced by plants and animals aid in dissolving other substances for assimilation and use. They are most active, when the temperature is 80° to 100° F. As the temperature recedes from this range, their activity decreases. They get quiescent at low temperatures and get active again when the temperature rises. Their activity is destroyed permanently in high temperatures.

When milk is kept over for 3 to 4 weeks, protected from the action of bacteria and other micro-organisms by the addition of substances like chloroform and ether, which inhibit the activity of the organisms, it undergoes proteolytic disintegration. It gets partially liquefied and the milk protein is partly converted to albumoses and peptones. The change is brought about by the enzyme *galactase*, that is present in milk.

Lipase, an enzyme that breaks down fats and produces glycerine and free fatty acids, is also present in milk. Butyric acid is one of the lower fatty acids produced by the lipolysis of butter-fat. It has a characteristic repulsive smell and acrid taste, which defiles milk products.

Reductase is an enzyme that brings about reduction of substances that part with their oxygen readily. Bacteria that are present in milk increase the quantity of reductase in milk, more or less in proportion to their number. When suitable dyes like methylene blue are added to milk under standard conditions, the time taken for the discoloration of the dye is taken to be a measure of the bacterial content of milk. This is an accepted standard test that is in common use in Western countries. One c.c. of standard methylene blue solution is added to 10 c.c. of milk and incubated at 98° to 100° F. The time taken for the disappearance of the bluish-green colour of the mixture, that is, the time of

reduction is indicative of the bacterial content of milk and its keeping quality. The following data illustrate this:

Class of milk	Time of reduction	Approximate keeping quality of milk in hours	Approximate bacterial numbers per c.c.
I. Good ..	5½–9 hours	40	less than 0·5 millions
II. Average ..	2–5½ hours	30	0·5–4 millions
III. Bad ..	20 minutes to 2 hours	10	4-20 millions
IV. Very bad..	less than 20 minutes	less than 10 hours	more than 20 millions

Colostrum.—The secretion of milk commences in the udder of mammals, a little before parturition. The first milk drawn after parturition is very different from that secreted a few days later, that is, normal milk. Since the milk secreted immediately after parturition differs from normal milk, it is sometimes called abnormal milk; it goes by the name of 'colostrum'. It is very thick, yellow, opaque and sticky to the feel. It has a specific gravity ranging from 1·60 to 1·75 and a high natural acidity of about 0·4 per cent., both much higher than in normal milk. The composition of colostrum and milk are given below:

	Colostrum (1)		Normal milk (2)	
	Sindhi cow	Murrah buffalo	Cow	Buffalo
Specific gravity ..	1·063	1·074	1·030	1·033
Acidity	0·41	0·35	0·12 to 0·16	
Water	81·8	71·1	85·28	81·74
Total solids ..	18·2	28·9	14·72	18·26
Solids-not-fat ..	16·2	15·0	9·05	10·15
Lactose	2·2	2·2	4·69	5·00
Ash	1·0	1·1	0·76	0·82
Fat	2·0	3·9	5·67	8·11
Proteins	12·8	21·4	3·60	4·33
containing, casein	4·0	6·8	..	..
albumin	2·6	3·8	..	..
globulin	6·2	10·8	..	..

Source: (1) Mukherjee, Swaminathan and Viswanath, *Indian J. of Vet. Sci. and Anim. Husb.*, 1936, 234 and 241.

(2) *Memoirs of the Dept. of Agric.* (*Chem. Series*), 2, 8 and 139.

Colostrum coagulates readily on being heated, due to its very high albumin and globulin content and high natural acidity. Normal milk contains only lactose, while colostrum contains both lactose and dextrose. The colostral character lasts for a period of 3 to 7 days from parturition, with a gradual change-over in composition and consequent loss of the heat coagulable property. The composition of milk is ordinarily normal from the eighth day onwards.

Colostrum is a highly beneficial food to the newly born calf, chiefly because of the anti-bodies associated with the globulin and the high content of vitamin A, which protects the delicate intestines from invasion by bacteria. It is highly laxative and it was considered formerly that loosening the bowels of the new born calf was the chief function of colostrum. Its laxative property is only of secondary importance. Immunising the intestines and promoting the capacity to form anti-bodies in the calf system are the more important valuable properties of colostrum.

Pre-milking cows.—The secretion of milk starts in the udder 3 to 15 days before parturition, earlier with heavy milkers and later with poor milkers. The udder swells consequently due to the pressure of colostrum that collects inside. This is a source of pain and great discomfort to heavy milkers. They get restless. The engorgement of milk sometimes leads to mammitis and the cows are milked before the birth of the calf to prevent inflammation developing in the udder. When once the milk is drawn, further secretion of milk is stimulated and milking has to be continued, even though parturition has not taken place. This is called 'pre-milking'. When cows are pre-milked, the milk is colostral in the beginning and becomes normal in 3 to 7 days. The milk secreted by pre-milked animals at the time of parturition is only normal and not colostral. The calves of pre-milked cows are unthrifty and subject to diseases in early life, with a tendency to high mortality. Large dairy farms in America freeze the pre-milked colostrum and feed it to calves after thawing, in the order in which it had been

drawn and frozen. It is said that calves that receive preserved colostrum get on as well as those that receive fresh colostrum. Further, they are not subject to disorders of the stomach, unthriftiness and early mortality, like those deprived of colostrum. Thus, preserved colostrum is a perfect substitute for fresh colostrum and preserving colostrum gets over the disabilities associated with pre-milking.

Slimy or ropy milk.—Milk sometimes develops sliminess on keeping, in temperate regions. Cows wading through marshy places carry about their flanks and udder the bacteria that produce this change in milk. The organism concerned is *Bacilli lactis viscosus*, which passes from the cow to the milk. It develops during the storage of milk and produces a gum-like protein from casein. Gelatinous capsules also develop round the organisms. Both these give the sliminess. When milk is poured from one vessel to another, it is seen to be viscous, ropy and oily, both in feel and appearance. This condition is not met with in South India, as milk is boiled here. The interval between milking and boiling is too short to develop the organisms in milk to any large extent and those that are present are destroyed during boiling.

The ropy condition is, however, sometimes met with in curds and buttermilk in South Indian homes. Slimy curd is unpleasant to consume. This condition is caused by the transference of the specific organism from the cow to the curd through vessels used in handling milk. When once the organism gets in, the curd continues to be ropy day after day thereafter, till it is rectified by sterilising all the vessels used in handling milk and milk products and using buttermilk of normal and good quality obtained from some other source, for initiating the fermentation in milk and the production of curd.

CHAPTER XIV

BACTERIA IN RELATION TO MILK

Entry of bacteria into milk.—Bacteria abound in large numbers everywhere, in the atmosphere, cattle stalls, milk utensils and equipment used in the dairy, the animal's coat, etc., and get into milk naturally, so that even fresh milk contains a good number of bacteria. The bacteria in fresh milk are derived to a large extent from the cow's teat, but not from the milk cistern or the animal system, except when the animal is in a diseased condition. The first few jets of milk contain a large number of bacteria and their rejection at the time of milking reduces the number of bacteria in fresh milk. The strippings or the last milk drawn from each teat contain very few bacteria. The underside of the cow, the udder, the flanks and the tail are in contact with dung, urine and the soil, and are heavily laden with bacteria. When the cows are kept in clean stalls, with the hairs about their flanks and udder closely clipped, and are brushed daily and washed periodically, the contamination of milk with bacteria from the animal body is considerably reduced. The cow's udder also requires to be washed and wiped with a clean dry towel just before milking, to ensure clean milk production.

The utensils used for handling milk in this country are not satisfactory. There are odd corners and dents in the vessels, which render cleaning difficult. Certain milk cans are made of galvanised sheets and the overlapping edges are held together by rivets. These joints cannot be cleaned easily and they harbour dirt and large numbers of bacteria, which pass on to milk. Also, no attempt is made to sterilise the vessels.

Bacteria and the cattle shed.—The cattle sheds in India have earthen floor in general, which gets soaked with urine and dung. Bacteria multiply rapidly under such conditions and pass on to everything connected with the cow and the

milk. The smell of manure that prevails in most cattle stalls tends to taint the milk. The importance of providing clean stalls, in the interest of the production of quality milk, cannot be over-emphasised. The provision of an impermeable floor for cow stalls and of drainage for carrying away urine and wash water greatly facilitates the production of clean milk. Even when the stalls are kept clean, bacteria are present in the atmosphere. When manure is being collected and fodder is being shaken about the cattle shed, the atmosphere gets dusty and the dust settling on milk increases the bacteria in it.

Bacteria and water supply.—The water used for feeding cattle and washing utensils is a possible source of bacteria, passing on to milk. The water supply should be free of bacterial contamination either by sewerage or other sources, since *Bacilli coli*, and other undesirable organisms, or pathogenic bacteria may pass on to milk from water.

Attendants and bacteria.—The milkmen and the dairy attendants also contribute to the addition of bacteria to milk. Bacteria are present in large numbers about the person of the workers and their clothing, particularly those working in the field and the cattle stalls. They may sometimes be carriers of diseases and pass on specific pathogens to milk. Certain persons are typhus carriers. They are perfectly normal and healthy but have typhus organisms left in their system after an attack of typhoid fever. This is not normal and systematic follow-up investigations of typhus incidence in other countries have shown that such people working in dairies, bakeries and food houses are permanent foci of infection. Similarly people coughing near milk could pass on septic sore throat and tubercular organisms to milk.

Bacteria from unhealthy animals.—Animal tissues are free of bacteria normally, except when they are in a diseased condition. Certain organisms carried by unhealthy animals pass on to milk sometimes. *Mycobacterium tuberculosis*, the tubercular organism, *Brucella abortus* causing contagious abortion in cattle and undulant fever in human beings and

various *Staphylococci* causing septic sore throat can be passed to milk through the cow's system. Various precautionary measures are taken in Western countries to check contamination of milk by such organisms. The cows and their attendants are periodically checked up. Still milk has been known to be responsible for epidemic diseases breaking out now and then. Bulking and distributing milk and direct use of pasteurised milk without subsequent heat treatment at home are the weak points in the distribution and consumption of milk in Western countries. The spread of infectious diseases in epidemic forms through milk can be said to be unknown in India. Milk is distributed in general by small producers and not by large concerns. It is generally boiled on receipt and before consumption. These are effective normally in preventing epidemic diseases spreading through milk on a large scale.

Bacteria get into milk in various ways as indicated above, multiply rapidly under the prevailing temperature conditions and affect the keeping quality of milk. It is therefore necessary that precautions should be taken at all stages to keep down the number of bacteria in milk.

Types of bacteria in milk.—Various types of bacteria may be present in milk. Some general purpose bacteria that are present are not specifically beneficial or harmful and their presence in milk is not a matter of moment. Others produce specific effects on milk, which are desired at certain times and not wanted at other times for various reasons. Important types of bacteria that are specific for milk will be considered now.

Streptococci lactis and *S. cremoris* are the organisms mainly responsible for the souring of milk. They enter milk from the cow shed, milk utensils and the body of the cow. They are most active at 70° to 95° F. and change the lactose in milk to lactic acid and small quantities of certain other organic acids. They induce the souring of milk and reduce its keeping quality. They are not therefore desired in milk. They are, however, used for the produc-

tion of curd, butter and cheese. They multiply rapidly and produce sufficient lactic acid in milk under conditions favourable for their multiplication and keep in check other types of organisms. When the acidity of curd reaches 0·8 per cent., the activity of the organisms is reduced, and completely checked when the acidity reaches 1·0 per cent. There is no further rise in acidity.

Streptococci citrovorus and *S. paracitrovorus* are organisms associated with *S. lactis* and *S. cremoris*. They get active after a certain quantity of citric acid and citrates are produced by fermentation, along with lactic acid. The citrates are acted on by these organisms and diacetyl is produced. Diacetyl gives the characteristic nutty flavour to butter. When the acidity of the curd reaches 1·0 per cent., the diacetyl and the resulting flavour are reduced. The best flavour is obtained, when the fermentation is stopped immediately after the curd sets firm.

Streptococci lactis aromaticus, present in certain samples of buttermilk, produces large amounts of acetyl methyl carbinol and diacetyl, when small quantities of citric acid are added to the fermenting milk. *S. diacetyl aromaticus* is a related organism that produces the richest flavoured buttermilk.

Lactobacilli sp. gets into milk from the cow shed. It is also a lactose fermenter like *S. lactis* and *S. cremoris*, but it develops acidity in curd up to 4 per cent. *L. acidophilus* thrives best at 100° F. and *L. thermophilus* at a range of 125° to 145° F.

Besides the above, numerous types of bacteria are found in milk and milk products. Most of them are kept in check by lactic organisms, when milk is being ripened. When the temperature is not favourable for the development of lactic organisms or when the quantity of starter added is not sufficient, the rate of production of lactic acid is slow and other organisms develop freely in the milk. Some produce gassiness, and the flavour and aroma of the resulting curd is impaired. Some proteolytic organisms also develop, which digest the casein and liquefy the curd.

Effect of bacteria on milk.—Milk is a nutritive substance, extremely suitable for the development of bacteria. Nitrogen, sugar, phosphorus, sulphur and mineral salts are present in milk in forms that are easily assimilable. Naturally, bacteria that get into milk thrive and multiply rapidly. As they multiply, the waste products of their metabolic activity accumulate in milk and retard their further multiplication. For example, lactic ácid produced by the fermentation of milk keeps in check the multiplication of the lactic organisms themselves beyond a limit, as indicated already. The following are the main chemical changes milk undergoes, as a result of bacterial activity:

(1) Lactose is converted to lactic acid and small quantities of acetic, butyric and carbonic acids are formed along with it. Acetic acid and butyric acid impart a bad smell not desired in milk products. Carbon dioxide produces gassiness in curd.

(2) The milk fats are hydrolysed, and free fatty acids and glycerol are produced, which induce rancidity in butter and ghee.

(3) The casein is liquefied by proteolytic organisms and the resulting material lacks the flavour of lactic curd.

Reducing the number of bacteria in milk.—It has been seen how bacteria get into milk. Dairy management practices, that reduce the entry of bacteria into milk at the several stages, are effective in reducing the total number of bacteria in milk. The points to be borne in mind in this regard are recounted below:

(1) Milk of only healthy animals should be used.

(2) The water supply to the animals and the dairy premises should be clean and free from contamination by sewerage. Water from deep wells provided with walls all round contain fewer bacteria than surface sources, like rivers and ponds.

(3) The cows should be groomed daily to remove the loose hairs, pieces of cow dung and mud sticking to their body, particularly about the flanks, hips and the udder.

The udder should be washed with water and wiped dry, before milking.

(4) The milk-men should have clean bodily habits, use clean clothing and clean their hands with soap before milking and handling milk utensils. The habit of dipping the fingers in milk, while milking to provide light lubrication is a reprehensible practice. Vaseline or butter may be used for the purpose.

(5) The milking should preferably be done in a separate milk shed, kept clean and well ventilated.

(6) The first few jets of milk from each teat should be rejected, as they contain a large number of bacteria. The use of hooded milk pails prevents dust falling into milk, while it is being drawn from the cow. The milk should be removed from the cow shed immediately after milking and kept in a clean cool place in order to prevent further bacteria getting into it from the cow shed and also to keep down its temperature.

(7) Dust and dirt are the chief carriers of bacteria and all practices should aim at reducing them in the milking shed and the milk storage room. Milk should be filtered immediately after milking to separate any dust that may have got into it. This does not, however, reduce the number of bacteria in milk. Cleaning the stalls and providing dry fodder in the manger should be done after milking.

(8) Flies should be kept out of the milking shed and the dairy. They hover over insanitary places and carry about their legs and hairy appendages a large number of bacteria, including possibly pathogenic organisms. These bacteria can be transferred to milk by the flies settling on the milk vessels.

(9) The utensils used for handling milk should be cleaned properly and sterilised immediately after use, to prevent them from carrying bacteria and passing on to milk. Drying in the midday sun raises their temperature to 140° F. and more in the tropics and is efficient in sterilising the milk utensils.

Clean milk can be produced by bestowal of care and attention at all stages of production and distribution of milk. This is an aspect which does not receive adequate consideration from the producers of milk in this country, and there is a woeful lack of sanitary consciousness in them, with the result that the milk produced in general has a large number of bacteria. It is not as though clean milk cannot be produced under the prevailing climatic conditions. The milk produced at the various dairy institutes are of satisfactory quality in this respect.

Dairy utensils.—The utensils used in the dairy should primarily be non-corrosive and resistant to acids associated with milk and milk products and should not be capable of passing on metal taint to milk. They are constantly handled and should therefore be made of metals capable of standing wear. They should not get dented easily and should be light in weight consistent with strength and durability. Aluminium is light and non-corrosive, but does not wear well. It is also easily dented, which renders proper cleaning difficult. Stainless steel is ideal for handling milk, but is too costly for general use. It is used for making cream separator disks on account of their capacity to stand wear. Milk buckets and churns are made of tinned steel and are quite satisfactory.

Earthenware commonly used in the household for handling milk is unsuitable. The pores in earthenware harbour bacteria, which render sterilisation rather difficult. Water is usually boiled in earthenware for sterilising it, but may be ineffective when it is not done thoroughly, as the material is a bad conductor of heat. Brass vessels are often used for transporting milk. Brass, iron, zinc, copper, the common metals used for fabrication of vessels, are subject to corrosion by milk acids. Metal taints in milk promote the oxidation of olein in the fat and this results in tallowiness in the butter. Brass, copper and ironware can be tinned and used safely for handling milk. Milk churns made with galvanised sheets with riveting, are often used for

transporting milk. The zinc used for galvanising is subject to corrosion by milk acids and so galvanised iron utensils are extremely unsuitable for handling milk.

Butter making equipment is made of wood. When it is soaked with water, the pores on the surface are filled with water and the films of water on the surface prevent the adhesion of butter-fat particles to the equipment. But the pores can harbour bacteria, when the surface is not kept clean and sterile.

Cleaning dairy utensils.—Dairy utensils are first cleaned with water for the removal of the milk solids adhering to the surface. The use of hot water for this purpose would coagulate the albumin in the milk films, which would then stick to the surface of the vessels and render cleaning difficult. After the removal of milk solids, the utensils are washed in hot water, for melting and removing the fat adhering to the surface. Even so, some fat is left behind and the vessels are scrubbed with a mixture of soda ash and sodium metasilicate, the former for dissolving fat and proteins and the latter for improving the wettability of the soda ash. Trisodium phosphate is sometimes added to facilitate the rinsing of the vessels free of soda ash and other substances, by detaching them from the surface. The utensils are finally washed with hot water for removing the detergents used.

Sterilising utensils.—Dairy utensils are finally sterilised after washing with chemicals, hot water or steam. Sterilisation in dairy practice refers to the destruction of vegetative forms of bacteria and not necessarily spore forms. Rinsing the vessels in a solution of bleaching powder, containing 50 to 100 parts of chlorine per million is a convenient form of sterilisation. It does not leave behind any odour of chlorine on the vessels at this strength. Sterilisation can also be effected by keeping the utensils immersed in hot water at 175° F. for 20 minutes or in boiling water for 5 minutes. The utensils can, instead, be subjected to live-steam for a period of 5 minutes. Treatment with chlorine is satis-

factory and convenient, though the other methods are more effective. After the heat or chlorine treatment, the surplus water is drained and the vessels are allowed to get dry. Wiping them free of water with dry cloth nullifies the effects of sterilisation, as the bacteria on the cloth are left on the sterilised equipment.

Cleaning butter making equipment.—The churn, butter-worker, Scotch hands and butter-boards used in making butter are made of wood. They are cleaned with hot water for removing the stray fat particles that may be left on the surface and finally scalded with boiling water, containing a little washing soda. When the water is drained, the heat absorbed by the surface assists materially in drying the wood. The butter-worker is scrubbed with dry common salt once in a way to clean the surface. Frequent scrubbing makes the wood surface rough and the fat particles would then tend to s ick. When the butter-worker gets sticky due to the impregnation of fat in the pores of the wood, a thin coat of lime may be applied and washed off after 5 to 6 hours. When the surface gets rough, it may be rubbed smooth with fine sand paper.

Preventing the increase of bacteria in milk.—If milk is cooled to 50° F. immediately after it is drawn, the bacteria present in it do not multiply fast and the milk keeps sweet for a fairly long time. Tap water is used for cooling the milk in temperate countries. It is obviously unsuitable in the tropics where the temperature of the tap water ranges from 70° to 90° F. Refrigeration is too costly and beyond the means of producers as well as consumers of milk. The principle of cooling the milk to prolong its keeping life is of limited applicability under Indian conditions.

Pasteurisation.—Pasteurisation is the name given to the heat treatment of milk in the dairy, which kills most of the bacteria present and reduces their number. Yeasts and fungi present in milk are also destroyed during the treatment. It aims primarily at the destruction of **all** pathogenic organisms that may be present, if any, and secondarily at the

reduction of the total number of the other types of bacteria. When the bacterial content of milk is reduced, its keeping life is increased, provided the few bacteria left behind are kept in check and not allowed to multiply rapidly later. Since pasteurisation aims at the destruction of pathogenic organisms, it is necessary that all the particles of milk should be held at the required temperature for the specified time. In day to day pasteurisation, milk is held at 143° to 145° F. for 30 minutes in what is called the 'holder' method of pasteurisation and at 160° F. for 15 seconds in the 'flash' or high-temperature short-time (H.T.S.T.) method. By such heat treatments, 90 to 95 per cent. of the bacteria in milk, inclusive of all pathogenic bacteria, are killed. But spore forms and thermoduric and thermophilic organisms survive. Spore forms are not usually present in milk. The thermoduric organisms survive the temperature of pasteurisation and get active when the temperature comes again to normal. The thermophilic organisms are active at 140° F., the temperature of pasteurisation in the holder method. Pasteurisation is effective in keeping the bacterial content at a low level, only if precautions are taken to prevent the subsequent contamination of milk by bacteria and if the surviving bacteria are kept in check by keeping the temperature of milk at about 40° F.

Pasteurisation of cream.—Cream is pasteurised at 155° to 165° F. by the holder method and at 180° to 185° F. by the H.T.S.T. method, that is, at temperatures higher than those used for milk. The cream consequently takes a light cooked flavour, which is not, however, perceptible in butter, after it is held in storage for about a week. If cream has developed acidity, it gets curdled and lumpy during heating. So, it is neutralised before pasteurisation, when necessary.

Pasteurisation in Western countries.—The pasteurisation of milk and cream is a common dairy practice in Western countries, which is valued for the following reasons:

(1) Pasteurised milk and cream are devoid of pathogenic organisms and are consumed as such, without any further treatment, as being safe.

(2) Pasteurisation reduces the bacterial content and improves the keeping life and quality of milk, facilitating its transport over long distances.

(3) The temperature used for pasteurisation does not alter the original flavour of the milk. Higher temperatures induce a cooked flavour, which is not liked by the consumers in the West.

(4) The property of forming cream-line, that is, the rising of cream as a distinct layer over milk is not affected by the temperature used for pasteurisation, but higher temperatures destroy it. The quality of the milk is judged in Western countries by the depth of the cream rising to the surface of the milk in the bottle.

(5) Pasteurisation destroys most bacteria; and so, the type of fermentation desired during the ripening of the milk and cream could be controlled by inoculation with suitable starter or culture material. If untreated milk is ripened, the organisms present in the milk and starter multiply side by side and the type of fermentation is of a mixed type and is not under control. The curd produced is thus liable to vary in quality from day to day.

Pasteurisation in India.—Pasteurised milk has supplanted raw untreated milk used for consumption in the European countries. It has many advantages over raw milk. The boiling of milk, however, before consumption is a universal practice in India. Pasteurised milk has not got such advantages over boiled milk, as over raw milk. Boiled milk is considered more agreeable for consumption than either raw or pasteurised milk in this country.

Further, pasteurisation of milk under Indian conditions is not effective in destroying most bacteria and many organisms present here are resistant to the temperature of pasteurisation. They multiply rapidly under the prevailing temperature conditions, as shown below:

Average bacterial content of milk produced at the Bangalore Institute Farm, under hygienic conditions, before and after pasteurisation

Number of hours after milking	Stage	Number of bacteria per c.c.
..	Milking pail	6,300
$\frac{1}{4}$	Weighing pail	27,300
1	In milk can	91,300
2	Bulked milk, before pasteurisation	225,000
$2\frac{1}{2}$	Same milk, after pasteurisation	9,400
3	Same milk after bottling	15,000
18	Bottled milk returned after delivery	121,000

Source: *Report on the Marketing of Milk in the Indian Union*, 1950, pp. 133.

Pasteurisation increases the cost of distributing milk here, without improving the quality effectively. Holding pasteurised milk at 40° to 45° F. in refrigerators is very costly and not practicable. So, pasteurisation does not serve any useful purpose in India. It increases the cost of the milk, which is already the highest in the world.

The bacterial content of milk is considerably reduced by boiling it for 5 to 10 minutes. When boiled milk is kept in a closed vessel, it keeps well for 14 to 18 hours under the normal temperature of the tropics, that is, at about 85° F. Re-heating it after 10 hours of storage prolongs its keeping life by another 10 hours or so.

The holder method of pasteurisation.—Milk has to be maintained at a temperature of 143° F. for 30 minutes in the holder method of pasteurisation. This is done in different ways. Commonly, milk is kept in stainless steel containers surrounded by a water jacket, where water is maintained at 150° F. The milk is kept agitated gently with suitable paddle arrangement. It is thereby mixed up

thoroughly and heated uniformly. Milk is heated in another system, with the aid of moving tubular rotary coils, through which hot water or steam is passed. In a third system, the milk is allowed to flow continuously through pipes, which are kept heated. The milk is held at a temperature of 143° F. for 30 minutes, by adjusting the rate of flow of milk. In certain systems, the incoming milk flows over the hot tubes, through which the treated milk leaves the pasteurisation plant, which facilitates the heating of the former and the cooling of the latter and economises heating and cooling charges.

H.T.S.T. pasteurisation.—High-temperature short-time pasteurisation of milk was originally called 'flash' pasteurisation. The temperature is raised to 160° F. quickly and the heated milk is held at this temperature for a period of 15 seconds and cooled suddenly, so that it may be pasteurised efficiently, without acquiring a cooked flavour or getting caramelised. The milk is usually allowed to flow in thin layers over flat surfaces, kept at a suitable high temperature, with hot water flowing in a direction opposite to that of the flow of milk. Less commonly, the milk is heated, by passing it through steam jacketed tubes. The time and temperature are suitably adjusted with automatic arrangements, in all the methods.

Pasteurising bottled milk.—Milk is also pasteurised in bottles, which is convenient for retail distribution. The bottle containers are sterilised, filled with milk at 147° F., sealed with renewable caps and kept in water-bath maintained at 147° F. for 30 minutes. The pasteurisation of milk in the bottle ensures that milk is not contaminated after pasteurisation, but the cost of heating and the equipment is considerably increased. Still, it is popular. It cannot be definitely said that all the particles of milk are heated uniformly.

Cooling milk after pasteurisation.—When milk is pasteurised, the number of bacteria present is considerably reduced, but those that survive are capable of multiplying

fast in the warm treated milk. This would defeat the very object of pasteurisation. It is therefore cooled suddenly and maintained at 40° to 50° F., so that the surviving bacteria may be rendered inactive and the milk kept sweet for a reasonable length of time. The cooling may be done with plate coolers, similar in principle to those used for pasteurising milk. But more commonly the coolers are made of horizontal tubes, placed serially one over the other, with the milk flowing over them in thin layers. Tap water is used as the cooling medium in the upper part of the cooler in temperate countries and brine at a lower temperature in the lower sections; and these bring about the cooling of the milk efficiently and economically.

Homogenisation.—When milk is forced through minute openings under high pressure of 500 to 2,000 lb. per square inch, the particles of milk are subdivided and increased in number a thousand-fold. The mean diameter of the particles is reduced from about 3 microns to 0·3 microns. This is called 'homogenisation' and the milk so treated is called 'homogenised milk'. The minute fat particles in homogenised milk do not separate out as in untreated milk. It is not possible to separate the cream from homogenised milk and make butter out of it. Homogenisation increases the viscosity of milk. Homogenised milk and cream have a rich taste, not to be had from untreated milk. It is easily digested in the system. Homogenisation improves the quality of manufactured products like condensed milk and milk powders.

Homogenisation is also effected with ultrasonic vibrations of high frequencies of 1 to 2 million cycles a second. The highest note audible to the human ear is 40,000 cycles per second. The sonic vibrations are produced by attachments called 'transducers', connected to the wheels of milk transporting lorries. The sonic vibrations exert tremendous pressure, the bacteria are destroyed and the particles of milk are comminuted and subdivided as in the case of pressure homogenisers. It is in use in England on a small

scale. It looks probable that it may be extremely suitable for India, as the transducer attached to the milk transporting lorry can destroy the organisms in milk, without the heating and cooling adopted commonly for pasteurising milk. The distance or time over which milk has to be transported and the prevailing temperature would then cease to be a problem.

The grading of milk.—Milk is a very valuable and wholesome human food. When it is not handled carefully at the several stages, it gets contaminated with bacteria of various kinds, including pathogenic organisms and thus becomes dangerous to health. Milk is consumed in Western countries in the raw state without any treatment, excepting pasteurisation. The importance of the purity, wholesomeness and quality of milk are recognised and rules have been framed to safeguard them. Standards of composition and bacterial purity have been prescribed for milk offered for sale in different countries. Competent inspecting and executive staff regularly inspect the cows, the conditions under which they are kept and the way in which milk is produced and handled. They examine samples of milk produced and distributed at periodic intervals and the wholesomeness and purity of milk are thus attempted to be ensured. The control over the production and distribution of milk is effectively exercised in England, America and the European countries. Milk grades have been laid down and the milk supplied by individuals is offered for sale on the basis of these grades, with the implication that the milk offered satisfies the standards laid down.

Chemical standards.—Legal standards have been fixed for fat and solids-not-fat (S.N.F.) of milk in various countries and any milk having the constituents below the prescribed standard is treated as adulterated by the addition of water or abstraction of fat. This might be a hardship to the producer, where individual cows give poor quality milk. Certain countries have therefore prescribed presumptive standards for milk. Milk not coming to the standard is presumed to be adulterated, till the contrary is proved.

This is rather difficult, though the milk drawn straight from the cow may be furnished as proof of the poor quality of the milk produced. The presumptive standard for commercial milk in England and Wales lays down 3 per cent. for fat and 8·5 per cent. S.N.F. The Madras standard lays down 3 per cent. fat and 8·5 per cent. S.N.F. for cow's milk and 4·5 per cent. fat and 9 per cent. S.N.F. for buffalo's milk. It is also prescribed in addition that cow's milk should have a minimum of 0·5 per cent. of nitrogen and buffalo's milk 0·53 per cent. of nitrogen. Both should not leave a sediment of more than 5 parts per 100,000 of milk, on standing for 24 hours.

The following grades are prescribed for milk in England and Wales:

Grade	Standards prescribed
1. Accredited milk	(*a*) The herd should be examined for general health by a veterinary surgeon once in 6 months. The cows are not tuberculin tested and cannot therefore be said to be free of tuberculosis.
	(*b*) There should not be any discoloration of the dye within 4½ hours in summer and 5½ hours in winter, in the standard methylene blue test, (outlined earlier).
	(*c*) The milk should not contain coliform organisms, in prescribed tests.
	(*d*) These tests are to be done on samples of milk drawn at suitable intervals by health authorities.
2. Tuberculin tested	Same as above and the cows are tuberculin tested at regular intervals.
3. Tuberculin tested and pasteurised	(*a*) The milk should have been subjected to standard 'holder' or H.T.S.T. pasteurisation.
	(*b*) There should not be any discoloration of the dye in the standard methylene blue test, within half an hour.
	(*c*) The milk should not contain more than 330,000 bacteria per c.c.
	(*d*) The cows should be tuberculin tested at regular periodic intervals.
4. Pasteurised milk	(*a*) Laboratory tests (*a*) to (*c*) same as for (3) tuberculin tested and pasteurised milk, given above.
	(*b*) The condition of the cow is not stipulated.

CHAPTER XV

THE DAIRY PRODUCTS OF EUROPE

Certain popular commercial milk products were developed in Europe originally. Their manufacture has now spread to other countries like America, New Zealand and Australia, which produce large quantities of surplus milk. The various dairy products are made under hygienic conditions, with strict observance of cleanliness at all stages of production, which ensure wholesomeness and good keeping life for the products. The important common dairy products are cream, butter, cheese, ice-cream, condensed milk and milk powders and their manufacture will be considered here briefly.

Cream.—When milk is divided into two portions in a cream separator, with almost the entire quantity of fat concentrated in one of them, the portion containing fat is called 'cream'. Cream holds the fat dispersed in a small quantity of the milk serum. The other portion, which is almost devoid of fat, is called 'separated milk'. When milk is kept in a vessel and left undisturbed, the fat in the milk rises to the surface. The portion left over, after the fatty portion on the surface is skimmed, is called 'skim-milk'. In common use, the terms skim and separated milk are used, without any rigid distinction between them.

Cream setting.—Cream can be collected by keeping milk undisturbed in shallow or deep vessels for varying periods. The fat particles rise to the top, due to the difference in density between fat and other milk constituents. The fatty layer is gathered by skimming with perforated ladles. The perforations in the ladle facilitates the draining away of surplus skim-milk. This was the method of collecting cream in use in former days and one that is in use in the small European household even to-day.

Shallow setting.—In this method, fresh warm milk is kept in shallow vessels to a depth of 4 to 5 inches and left

undisturbed for about 24 hours. The fat particles rise to the surface and form a layer rich in fat at the top. This fat-rich layer constitutes the cream. As the depth of the column of milk is limited, the fat particles rise to the surface easily. The cream is skimmed with perforated ladles. This method of producing cream is still preferred by the small householder, as being simple, without any special equipment being needed. The quantity of fat left in the skim-milk is as high as 0·6 per cent. The skim-milk is obtained in a sweet condition in temperate countries and it is used for feeding calves, pigs and poultry. The butter produced has a better flavour than that made in dairies with cream separated by the cream separator. Household cream includes considerable quantities of milk serum and the flavour developed in the ripening milk serum is passed on to the butter. In dairy cream, the flavour producing milk serum is less in proportion and so, the butter has less flavour.

Deep setting.—Cream is collected here also, using the same gravitational method as in the shallow setting system. The milk is kept in deep vessels, to a depth of 6 to 12 inches, for creaming. The milk pans are placed in running cold water to assist the rising of the fat. The fat particles are solidified by the low temperature, their volume is increased, with a proportional rise of the difference in specific gravity between the fat and the milk serum. Since the fat particles have to rise over a larger column of milk, the time taken for creaming is greater than in the shallow setting system. The deep setting method is more convenient, where large quantities of milk are handled, with economy in vessels and space required. The fat left behind in the skim-milk ranges from 0·2 to 0·3 per cent. and is less than that left in the shallow setting.

Mechanical cream separation.—The cream separator is a machine that is used for separating the milk into cream and separated milk. The separation of the cream with the cream separator is instantaneous, and cream and separated milk are obtained in a perfectly sweet state. The separation

of the fat is also done efficiently and the fat content of the separated milk ranges from 0·03 to 0·05 per cent., equivalent to 0·75 to 1·25 per cent. on total fat in the original milk, when compared to about 15 per cent. in the shallow setting system.

It may be said that the invention of the cream separator has greatly contributed to the development of the butter industry to its present level. The cream separator was invented in 1872 and came into common use by the beginning of this century. In the dairy countries of the world, cream is at present separated and made into butter in factories handling thousands of gallons of milk each day. The production of cream in a sweet state, and the regulation of fermentation of cream and the various processes in butter making in the factory enable the production of standardised butter of a high and uniform quality regularly.

The cream separator is in various sizes, capable of separating 150 to 10,000 lb. of milk in an hour. Small separators handling up to 800 to 1,000 lb. of milk an hour are operated by hand, and the bigger units are operated by power. The essential constructional features are the same in both hand and power operated machines. There is a central bowl, called the 'separator bowl', rotating at 6 to 10 thousand revolutions per minute, where milk is distributed in thin layers by a series of disks, to facilitate the instantaneous separation of the cream. The centrifugal force to which milk is subjected is many times that of gravity and the difference between the densities of fat and solids-not-fat force the lighter fat particles to the centre of the bowl and the heavier separated milk to the periphery and the two separated fractions are discharged separately through their respective spouts.

The cream separator consists of three essential parts, namely, (1) the milk cistern supplying regulated quantities of milk to the bowl, (2) the rotating bowl where the cream is separated and (3) the mechanical arrangement which rotates the bowl at high speed.

The milk cistern is of various designs and is provided with a faucet at the bottom to regulate the delivery of milk to the bowl below. The milk is delivered to a cylindrical cup called the 'regulating cover', which lets the milk into the bowl. There is a hollow sealed loose 'milk float' in the regulating cover. It floats on the milk. If the passage to the bowl is blocked during operation, the level of the milk in the regulating cover rises, carrying up with it the milk float. It blocks the lower end of the faucet of the milk cistern and prevents the flow of milk from the cistern automatically.

The bowl bottom has a hollow stem on which a number of conical disks are stacked one over the other. The disks have small protuberances on the surface to provide a little space in-between the adjacent disks. They are enclosed in a strong bowl and kept in place by a bowl nut.

When the separator starts working, milk flows into the hollow bowl stem and passes to the bottom of the disks. The conical disks have three holes each, which form a channel for the milk to pass from the bottom to the top-most disk. While the milk passes through these disk channels, it gets distributed in-between the disks in very thin layers. These are subject to centrifugal force, which impel the heavy particles of milk to the periphery and the light fat particles along with a little milk serum to the centre. The central bowl stem deflects the cream and it moves upward along the bowl stem and gets discharged through the cream screw. The top disk is shaped like an inverted funnel and has the cream screw fixed on one side. This disk is without holes and prevents the cream from mixing with the separated milk. The cream is finally received by the cream cover, which is below the regulating cover.

The separated milk in the peripheral portion of the bowl is directed upward by the bowl hood. It is discharged through a horizontal slot at the top of the bowl hood, into the skim-milk cover, which is under the cream cover. The skim-milk and cream discharged through their outlets are collected separately.

FIG. 7. A diagrammatic sectional view of the cream separator

When the separator works, some of the bacteria, epithelial cells and dirt in the milk adhere to the inside of the bowl hood as a scum and when the separator is worked for a long time continuously, the thickness of the scum increases and reduces the efficiency of separation. The separators have therefore to be cleaned at suitable intervals in factories working long shifts.

Factors affecting the efficiency of separation.—The efficiency of separation of the milk depends on (1) the temperature of the milk, (2) the sweetness of the milk, (3) the speed of operation and (4) the proper adjustment of the separator.

(1) *The temperature of the milk.*—The viscosity of milk is reduced by rise of temperature and cream is separated efficiently at 90° to 95° F. Milk is therefore warmed in temperate countries at the time of separation; it is not necessary in the tropics, where the prevailing temperature may be near about 90° F. Though the viscosity of milk may be reduced further by higher temperatures, the efficiency of separation is not increased and further heating of milk is not done.

(2) *Sweetness of milk.*—When milk is kept over, its acidity increases and clots are formed. The clots enclose fat particles and do not permit efficient separation. In large creameries, the milk obtained from different sources are bulked and the acidity of the milk is tested and brought to normal by the addition of calculated quantities of sodium carbonate solution. If milk clots are present, the milk is strained through muslin cloth before separation, to enable the separator to work without clogging.

(3) *Speed of separation.*—The separator is designed to work at a certain speed. When it is worked faster, milk does not remain long enough on the separating disks and the efficiency of separation is reduced. When it is worked slower, the centrifugal force generated is not enough to separate the fat thoroughly and separation is again imperfect.

(4) *The adjustment of the separator.*—When the separator parts are assembled properly, cream is separated efficiently. The consistency of the cream is regulated by the inflow of milk through the milk faucet and the adjustment of the cream screw. When the faucet is opened fully, normal cream is produced. When the milk flow is reduced, the cream produced is thicker in consistency.

When the cream screw is pushed in, the space between the screw and the bowl stem gets less, the volume of the outflowing cream is reduced and the cream delivered is thick in consistency. When the screw is pulled out, thin cream is produced. In certain separators, the cream hole is fixed and the outflow of skim-milk is adjusted by a skim-milk screw. When this screw is pushed in, the skim-milk is reduced, the cream volume is increased and the resulting cream is thin in consistency. When the skim-milk screw is pulled out, thick cream is delivered.

When thick cream is produced during cold weather, it is likely to clog the separator occasionally. The milk faucet may then be closed and a small quantity of hot water may be fed to the separator, which would melt the cream and make the separator function again.

Cream output and consistency.—The quality of cream obtained depends upon its consistency, which is adjusted by the cream screw. Thick cream has a high fat content and thin cream, a low fat content. Cream with a fat content of about 30 per cent. is very suitable for making butter. When thinner cream is used, the fat particles do not get the necessary concussion during churning and some fat is lost in the buttermilk. When the cream is thick, it tends to stick to the churn, there is not sufficient concussion and fat is again lost. Thin cream with a fat content of about 20 per cent. is suitable for making coffee. Thick cream with about 38 per cent. of fat is extremely suitable for making whipped cream, which is used as a spread on pastries. Thick cream is viscous and when it is whisked briskly with spoon or special whipping equipment, it enfolds

air and gets fluffy. Special separators are used for obtaining extremely thick cream having 65 to 83 per cent. fat. Such thick creams are plastic like butter. They are passed through special homogenising, pasteurising and working machinery, after adding a little salt and, butter is produced in a continuous process. The average percentage composition of cream and that of skim-milk are given below:

Ingredients	Specific gravity	Thin cream	Thick cream	Plastic cream	Skim-milk
Fat ..	0·93	20·0	35·0	82·0	0·12
Protein ..	1·346	2·8	2·3	0·6	3·54
Lactose ..	1·666	4·2	3·4	0·9	5·21
Ash ..	4·210	0·6	0·5	0·1	0·73
Water ..	1·000	72·4	58·8	16·4	90·40

Cleaning the separator.—After the cream and skim-milk stop flowing from their respective spouts, a small quantity of warm water is used for flushing and the separator is worked a little. This assists in recovering the fat sticking to the bowl parts. The bowl is then allowed to come to rest by itself. Applying the hand to the bowl to slow down the movement is likely to upset the delicate mounting of the mechanism. After the bowl comes to rest, it is lifted from the supporting spindle and dismantled. The bowl parts are cleaned, sterilised, dried and kept assembled for use later.

Cream is a white, thick, viscous fluid, which contains almost the entire quantity of fat in the milk dispersed in a part of the milk serum. The colour of cream is variable. Cream produced out of cow's milk is light yellow. The depth of the colour varies with the breed and to an extent with the feed given. Green feeds intensify the colour. Cream from buffalo's milk is dull white in colour, without any yellow shade. The thickness and viscosity of cream increases with the fat content, and thick cream with about 80 per cent. fat is plastic like butter. The specific gravity

of cream is lowered by increase of fat content. Thus cream with contents of 20, 30 and 50 per cent. of fat have specific gravities of 1·013, 1·001 and 0·981 respectively. Milk and skim-milk have specific gravities of 1·032 and 1·042 respectively.

Skim-milk or separated milk is milk from which fat has been abstracted almost completely. It is therefore milk *minus* fat and it has all the nutritive properties of milk, excepting those provided by the butter-fat. There is thus loss of some calorific value and of fat soluble vitamins A, D and E. It is a debatable point whether milk has to be given a greater value for its fat or proteins. In practice, fat is given a very high value and protein is not given an equal importance. The milk fat has no specific superiority over other fats, though it carries an irresistible appeal on account of its special palatability, flavour and taste. The milk proteins on the other hand have a high biological value, not possessed by other proteins. From this point of view, skim-milk is as valuable as whole milk.

Skim-milk is a very valuable food. It is used largely for feeding calves, pigs and poultry in the important dairy countries. It is dehydrated and the dry powder obtained is used for making bakery products, ice-cream and reconstituted milk. It is also used commercially for the manufacture of casein and lactose.

CHAPTER XVI

BUTTER MAKING

Milk and butter are the two dairy products that are universally consumed in all countries. The production and use of other milk products are confined to certain countries only. When soured or ripened milk is gently agitated, the fat particles aggregate and form granules, which on bulking form a coherent mass, called 'butter'. This keeps longer in storage than other milk products, may in part account for the universal popularity of butter with the producer and consumer.

Butter—general properties.—Butter is an aggregate of the fat particles of milk. It contains nearly the entire quantity of fat present in milk, associated with a small amount of water and casein. Milk and cream are emulsions, with the fat particles dispersed in the milk serum. Butter is an inverted emulsion, where water particles in a fine state of division are dispersed in fat which forms the continuous phase. It is solid and plastic. It gets hardened when the temperature is lowered and softens when it is raised. Butter made with buffalo's milk is white in colour and that made with cow's milk is yellow. The depth of colour is a rough indication of the carotene content of butter. When the feed contains materials rich in carotene like grass, the yellow colour of butter is intensified. Certain breeds of cows give butter with an intense yellow colour. When butter is made properly, it keeps well for long periods, compared with other milk products, particularly under cold storage, without loss of flavour, taste, palatability and nutritive value.

Butter may be made either from milk or cream. The product is called butter in both cases, but for purposes of discussion in this section, we may designate them milk-butter and cream-butter, respectively. Milk-butter differs from cream-butter in the following respects:

(1) Milk-butter is lighter in colour.

(2) Milk-butter has a better flavour, as flavouring substances are produced in abundance by the larger quantities of milk serum present in association with the fat particles.

(3) Milk-butter is produced with proportionately larger quantities of churning fluid and this makes the production of butter on a large scale difficult and inconvenient.

(4) When cream is used for making butter, sweet skim-milk is obtained as a valuable by-product, which can be used in place of milk for many purposes. When milk is directly used for making butter, the buttermilk obtained by churning is the by-product. It is in a dilute and fermented state and cannot be so usefully and variously utilised as skim-milk.

(5) Milk-butter requires a higher churning temperature than cream-butter. The higher temperature does not conduce to the production of satisfactory granularity in butter.

(6) When milk is churned, small fat particles do not coalesce readily and are lost in buttermilk. The quantity of butter produced directly from milk is therefore proportionately lower.

Ripening Cream

Natural ripening.—When milk is kept over, the bacteria present in it multiply fast and increase its acidity. When the acidity reaches a critical limit, the milk coagulates and curd is formed. The souring of the milk is called 'ripening' and the curd is sometimes referred to as 'ripened milk'. The souring of milk, which takes place without the addition of any material for inducing fermentation is called 'natural ripening'. The types of bacteria inducing ripening in this method are not under control and ripening is not always of the same type. If, on the other hand, suitable types of bacteria are introduced into the milk, curd of the desired quality can be produced. Usually good flavoured buttermilk is added to milk, as starter for initiating the ripening. The material added contains suitable types of bacteria that initiate the fermentation and produce curd of good quality.

This material is called the 'starter'. The ripening caused by the addition of a starter is artificial ripening, but it is usually referred to as 'ripening'.

Ripening of milk.—The ripening of milk takes place satisfactorily at a temperature of 75° to 90° F. When the temperature of the milk is less, the lactic organisms are not so active and bitter flavours are likely to be developed, as a result of the activity of undesirable organisms which are capable of multiplying fast at the lower temperatures. When the temperature of ripening is higher, a certain oily flavour is developed in the butter that is produced. Milk or cream may be said to be properly ripened, when the curd produced is smooth in appearance and uniform in consistency with an agreeable flavour and a sharp acid taste. Presence of clots, frothiness, gassiness and collection of clear serum on the surface, liquefaction of casein in the lower layers, production of off-flavours, etc., are defects in ripened milk.

The viscosity of milk is reduced by the development of acidity during ripening. This favours the easy separation of the fat particles from the other ingredients in curd and their free movement and aggregation leading eventually to their coalescence during churning.

Starters.—These are added to milk for inducing ripening and contain lactic organisms preponderatingly. The organisms in suitable starters are capable of (1) multiplying fast at a temperature of 75° to 90° F. and producing a titratable acidity of 0·65 per cent. in 6 to 10 hours, (2) keeping in check other types of organisms that may be present in milk, (3) coagulating or thickening the milk uniformly, producing at the same time a sharp clean acid smell and taste, and (4) giving rise to butter that has an agreeable and characteristic aroma.

The usual material used as starter is a small quantity of curd or buttermilk. The latter is handled in different vessels and is likely to be contaminated by other organisms during churning. It is therefore preferable to use curd as starter. The top portion of the curd may be skimmed off

and a small portion of curd from the lower layers removed and kept closed in a separate vessel, for use as starter later. This largely avoids contamination of the starter and its deterioration.

Culture starters.—Cultures of suitable organisms are prepared in laboratories in the form of liquid or powder, for use as starter for initiating the fermentation of milk. The culture material is mixed thoroughly with a small quantity of sterile skim-milk, maintained at 75° to 90° F. The skim-milk gets ripened eventually. A small quantity of this is inoculated into another lot of skim-milk and left till it curdles. A small portion of the curd is added to a third lot of skim-milk and the resulting curd is used as regular starter material for use in the dairy, for ripening milk and cream. It may be carried forward from day to day, till it gets spoilt by contamination with unsuitable organisms, bacteria, yeasts, moulds, etc. If the laboratory cultures are directly inoculated into milk or cream, the taint of the culture media passes on to the ripened product. Further, the bacteria in the culture are also not likely to be quite active for the first few days and milk or cream may not be ripened properly.

Adding starter.—Starter is added at 2 to 5 per cent. of the weight of the cream under South Indian conditions. Less starter is used during summer and more during cold weather. The starter curd is broken up and stirred well into the cream, to distribute it evenly in the cream and obtain uniform ripening. Otherwise the starter curd may settle at the bottom of the cream and the lower layers may get ripened, while the top layers may remain comparatively sweet.

Successful ripening of cream requires

(1) a dry and a properly ventilated room with subdued light for keeping the cream;

(2) clean surroundings to avoid contamination by undesirable organisms and taints, which may be absorbed by the cream easily;

(3) a uniform and suitable temperature to promote rapid and uniform ripening (the temperature prevailing in South India favours rapid ripening of milk and cream); and
(4) the use of suitable starters, for inducing ripening.

Churning Cream

Churning equipment.—Churning cream and making butter are done in various types of churns. The barrel-shaped butter churn, called sometimes the 'end-over-end butter churn' is commonly used for churning with hand power. The churn is mounted on a horizontal axle that is fixed at the central bulged portion. It is provided with a lid and lever clasps to lock it firmly and make the churn water tight. The lid has a small glass window, which facilitates observation of the condition of the butter granules inside without removing the lid. There is a ventilator knob on the lid, used for letting out the gases formed during churning, by pressing the knob. There is a side opening near the bottom of the churn, for draining the buttermilk. This opening is closed with a slip-in tapering wooden plug.

Churning.—The cream is thinned suitably with water, for reducing its viscosity and permitting the liberation of fat globules from association with protein particles, and promoting the aggregation of the fat particles and forming butter grains. The churn is rotated with the diluted cream. When the churn is rotated, the bottom end goes up taking the cream along with it to the top. The cream drops down at this stage from the top to the bottom end of the churn. If the churn is rotated at the proper speed specified by the manufacturers, the regular dropping of the cream from one end to the other could be faintly, but distinctly heard.

The concussion theory of churning.—When the cream drops down from the top to the bottom of the churn, the fat particles collide with one another, coalesce, get larger and form butter granules. Eventually, the granules get bigger by further accretions. The collision between the fat

particles themselves and also between the fat particles and the buttermilk are collectively referred to as the concussion of the cream.

Factors Influencing Churning

(1) *Concussion.*—When the butter churn is rotated, the cream drops down from one end of the barrel to the other, the fat particles collide with one another with some force and the particles are subjected to a certain pressure or concussion. The tiny butter fat particles are in a state of dispersion in the milk serum. During churning, the tiny fat particles get massed into small granules, which grow in size by further accretions as churning proceeds. When the churn is filled to a third, good concussion is secured. Reducing or increasing the quantity of the churning fluid reduces the concussion and the time required for churning is increased.

(2) *Temperature.*—When the temperature of churning is high, the fat particles are soft and coalesce readily and the churning time is reduced. Conversely when the temperature is low, the churning time is increased. The best churning temperature is 55° to 58° F., which secures the maximum recovery of fat and the proper consistency and granular structure of butter.

(3) *The size of the fat particles.*—When the individual fat particles in cream are large in size, they coalesce readily and churning is quickly done. Small fat particles slow down churning. The individual fat particles vary in size with the breed of the animal, the individual and the stage of lactation. The fat particles in buffalo's milk are large in size and coalesce readily, but this is offset to an extent by the predominance of the harder fats. As lactation advances, the fat particles get reduced in size and if in a herd there are a number of cows in advanced lactation, churning is considerably slowed down.

(4) *The consistency of butter-fat.*—Butter-fat is a mixture of several fats, hard fats with high melting points and soft fats with low melting points. It commences melting at

88° F. and melting is complete only at 97° F. On cooling, it starts solidifying at 75° F. and solidification is complete at 66° F. When hard fats predominate, the churning is prolonged, while with soft fats the churning is quicker. The consistency of fats is largely influenced by the feed. Groundnut and linseed cakes produce a soft butter. Gingelly cake gives butter with normal consistency. Coconut cake, grains, cotton-seed and rice bran produce hard butter.

(5) *The consistency of cream.*—Too high or too low fat content in cream reduces the impact of the fat particles with one another and prolongs the churning. Thick cream is viscous and sticks to the ends of the churn. It tends to rotate with the churn and does not drop down readily from the ends of the churn and so, there is not sufficient concussion. This increases the churning time. When the cream is thin or diluted considerably, the individual fat particles are far apart in the liquid system, the number of impacts received by each particle is reduced and the fat particles do not coalesce readily. This also increases the churning time.

Cream with 30 to 35 per cent. of fat is suitable for churning. This is diluted with an equal quantity of water, so that the ultimate fat content of the churning fluid is about 16 per cent. When thin or thick cream is used, it may be diluted suitably, so that the churning fluid has finally a fat content of 16 to 17 per cent.

(6) *Degree of ripeness of cream.*—The acids produced by ripening reduce the viscosity of cream. If the cream is over-ripe, the viscosity is considerably reduced, but the casein particles get hardened and stick to the butter grains and are not easily washed out.

The process of churning.—Churning cream and making butter consists of a number of processes and they are considered below:—

(1) *Colouring butter.*—To give an attractive golden yellow colour and uniform appearance to butter in commercial concerns, colouring is resorted to. The various

aniline dyes are harmful to health and their use is prohibited by law in other countries. The use of annato is permissible. Annato is a vegetable dye, obtained from the Latka tree, *Bixa orellana*. It grows wild in tropical jungles. The pulp surrounding the seed gives the dye. The seeds are macerated with 3 parts by weight of some sweet oil like gingelly and boiled for some time. The dye is drawn by the oil. The oil is then filtered through muslin and used for dyeing cream. The dye is also extracted with soda, alum and water for use in cheese making.

The annato in oil is standardised and used for giving a uniform colour to cream, at about 2 drops of the extract to a pound of cream. The dye is mixed well with the cream, before commencing the churning.

(2) *Diluting the cream*.—Cream with a fat content of 30 to 35 per cent. is used for making butter. It is thick and viscous and is diluted with an equal quantity of water, to make it suitable for churning. The temperature of water is used for adjusting the temperature of the churning fluid to 58° F. The mean of the temperature of the cream and water is roughly the resulting temperature of the churning fluid, when equal quantities of cream and water are mixed.

(3) *Filling the churn*.—The churn is filled with diluted cream to about one-third the volume of the churn. Loading the churn with greater quantities or less, reduces concussion and prolongs churning. The extraction of fat is also less.

(4) *Preliminary churning*.—After loading the churn with diluted cream, the churn is closed, and rotated steadily and uniformly at the rate specified by the manufacturers. Most of the hand operated churns are designed to be worked at 40 to 60 revolutions per minute. During churning, the sound of falling cream is heard. Gases, chiefly carbon dioxide, are given off during the early stages of churning and are let out at intervals by pressing the ventilator knob. If the gases are not released, the cream froths up, butter granules do not form properly and a considerable amount of butter will remain in the buttermilk, unextracted.

(5) *Breaking stage.*—As churning is continued, the tiny fat particles coalesce, get bigger and bigger and become visible as small independent granules. The glass window that was opaque originally, due to the adherence of the cream emulsion, begins to clear. The butter granules are seen to be sticking to the glass window as small specks and buttermilk is also seen to be draining from the glass. This is the stage when the fat particles break off from the emulsion phase, that is, the butter granules are simply suspended in the buttermilk, instead of being dispersed in the cream as an emulsion. This is called the 'breaking stage'. The sound of the falling liquid inside the churn changes its character, the thud sound gives place to a sharp sound.

The churning is stopped, when the fat particles are about the size of small pin heads. The temperature of the churning fluid is 2° to 3° F. higher than at the commencement. This is due to the work energy of the falling cream having been converted to heat energy. A small amount of heat is also given off when the fat particles change over from the colloidal dispersion phase to the solid aggregation phase.

Cold water at about 50° F. equal in quantity to the churning fluid is now added. This is called the 'break-water'. The temperature of the churning fluid is reduced to 55° F. by the addition of break-water. The lowering of the temperature prevents the butter granules developing fast. The addition of water fills the churn up to two-thirds. The increase of the fluid in the churn reduces the concussion and the rate of development of the butter grains. This prevents buttermilk being enclosed within the grains. The churning is continued till the butter grains are about the size of sorghum grains, or roughly one-eighths of an inch across. The churn is now rotated slowly and given a few rocking motions to and fro, to make the butter grains rounded and smooth, so that much buttermilk may not stick to them.

(6) *Washing butter.*—The buttermilk in the churn is drained through a muslin cloth held over a horse hair sieve.

The cloth retains butter grains that pass along with the draining buttermilk. The churn is plugged and water at 2° to 3° F., lower than the churning temperature and equal to the volume of the buttermilk drained, is added to the churn. It is rotated slowly for a while to wash out the buttermilk that may be adhering to the butter grains and the wash water is drained. A second wash is given, using an equal quantity of water at a slightly lower temperature. When the temperature is lowered gradually, the butter grains get hardened.

(7) *Brining.*—The second wash water is drained and brine made with 1 to 2 lb. of salt to a gallon of water at 2° to 3° F., cooler than the second wash water is added to the churn and kept for half an hour. During this period, the butter grains absorb salt evenly and get hardened. About half an ounce of salt may be absorbed by a pound of butter. Brining, however, is costly and unnecessary. It is not commonly done.

(8) *Working butter.*—The butter grains floating on the second wash water or on brine, as the case may be, are gathered with a perforated wooden scoop and transferred to the butter-worker. The wash water in the churn is drained through muslin cloth and stray butter grains caught by the muslin cloth are also transferred to the butter-worker.

Most of the water adhering to the butter grains gets drained in a short time. The roller of the butter-worker is then run from the upper to the lower end. The butter grains are thereby pressed and excess water is pressed out. The roller may be passed over the butter to and fro a few times. When the roller is at the lower end, the end of the spread-out butter is lifted with Scotch hands and the roller worked in the reverse direction, when the butter collects as a roll. It is picked up with Scotch hands and placed in the centre of the worker lengthwise and the roller is worked over the butter. This expels the water further. If the butter roll is placed breadthwise across the direction of working of the roller, the water present would be worked into the butter

and this has to be avoided. Table salt is sprinkled over evenly, at ½ of an ounce per pound of butter, in 2 or 3 instalments and the butter is worked again. Fifty per cent. of the salt sprinkled is retained by the butter and the rest is drained with water, while working. The working of butter has to be done rather rapidly in the tropics, to avoid butter getting soft by rise of temperature and losing its granular structure. After the water has been expelled by working, the butter is gathered and made into packets of suitable sizes.

The number of times the roller is worked would depend on the size and hardness of the butter grains, and the atmospheric temperature. Water is easily expelled from large sized butter grains, properly hardened by chilling, during washing. Over-working makes the butter pasty. Good butter may be spoilt by keeping it too long on the butter-worker. Working the butter aims at the expulsion of the free water in the butter grains and the dispersion of the residual water in butter in the form of minute droplets.

(9) *Testing the water content of butter.*—If a small quantity of butter taken from the centre of the butter roll is pressed firmly between the Scotch hands, excess water in butter, if any, drips from the butter.

If the butter roll is cut across and small portions are scooped out from the cut surface, excess water, if any, oozes out from the hollows made. The cut surface should not show visible droplets of free water.

(10) *Packing butter.*—The worked butter is transferred to butter-boards and made into packets. Usually 1, 2, 4 and 8 ounce packets are made for local retail sales. The packets are made with butter-paper which is water and grease proof and kept in cold storage. A neat and distinct finish to the packets appeals to the customer and is appreciated. The butter develops its full flavour after 3 or 4 days of storage.

Butter quality.—This is determined by (1) texture, (2) moisture content, (3) flavour, (4) aroma, (5) colour, and (6) keeping qualities.

(1) *Texture.*—When butter is cut across cleanly, the surface should present a solid texture. When a piece of butter kept in cold storage is separated into two pieces, the separated surfaces should present a closely granular appearance, without any jagged edges. Jagged edges are associated with vaseline-like pasty butter.

(2) *Water content.*—There should not be any free droplets of water visible, when the butter is cut across. When it is pressed with Scotch hands and water does not ooze from it, it can be said to have the proper amount of water dispersed in it.

(3) *Flavour.*—Butter should have its characteristic fresh nutty flavour, which has an appeal to the palate. Flavour is the smell that pertains to the particular substance.

(4) *Aroma.*—The aroma of butter should be full, sweet and free from oily, rancid or other off odours.

(5) *Colour.*—The natural colour of cow's butter is pale yellow. It should be uniform, light, natural and pleasing.

(6) *Keeping qualities.*—When creamery butter is kept in a cool place, under ordinary conditions of storage in the tropics, away from strong smelling substances like meat, cheese, onions, etc., it should keep well for about a week and for at least 4 to 6 months in refrigerated storage.

Butter made in creameries has generally the following percentage composition:—

	Water	Fat	Proteins	Lactose	Ash	Salt
Salted butter ..	12·5	83·5	0·5	1·5	0·2	1·8
Unsalted butter ..	14·0	83·5	0·8	1·8	0·2	..

Over-run in butter.—Cream is purchased for the manufacture of butter on the basis of the fat content. The butter produced is always more than the calculated quantity of fat. The excess is caused by the presence of water and curd particles in butter and added salt. This is referred to as 'over-run'. The water present in butter should not exceed 18 per cent.

Defects in Butter

(1) *Streakiness and speckling.*—Butter is sometimes streaked white, speckled or mottled, when it is called streaky and mottled butter respectively. These are caused in various ways. When the salt used is impure or when it is not uniformly distributed, specks and discoloured patches develop in the butter. Uneven ripening of the cream often produces streaky butter. When the cream is over-ripened, the casein is precipitated as hard scales, which do not get washed out of the butter grains properly and specks are formed later, during storage. Portions of butter exposed to strong light are bleached and the colour of butter tends to become uneven.

(2) *Rancidity.*—When butter is held in storage, the moisture hydrolyses the fats and liberates free fatty acids like butyric and caproic acids, which have a characteristic unpleasant rancid smell. Rancidity in butter is objectionable, but is not common, except when creamery butter is held in storage for long.

(3) *Food taints.*—Feeding cows with strong smelling feeds like cabbage before milking passes the characteristic taint to milk and butter. Feeds having strong taints may be given after milking, when the taints are not passed on to milk.

(4) *Sour flavour.*—When butter is not properly washed, the curd acids are included in the butter and give it an acid smell.

(5) *Musty odour.*—When moulds develop on the surface of butter held in storage, a musty odour is produced.

(6) *Starchy taste.*—When butter is over-worked, the granularity of butter is lost and a pasty mass results. This does not dissolve on the tongue and gives a starchy taste to butter.

(7) *Tallowy smell.*—This is caused by the oxidation of the oleic acid in butter held in storage. There is slow absorption of oxygen. Oxidation of the oleic acid is prevented in the early stages by the presence of anti-oxidants that are

present in butter. They are dissipated after a time and oxidation takes place rapidly thereafter. The absorbed oxygen acts as a catalyst and speeds up further oxidation. There is rapid deterioration of butter and the development of a tallowy smell. Other causative agents are heat, light, acidity, moisture, enzymes and contact with metals like iron and copper.

(8) *Fishy smell.*—This is developed by the hydrolysis of lecithin present in raw milk. Lecithin is destroyed during pasteurisation and lipolytic hydrolysis does not set in, in butter made with pasteurised milk. In butter made with raw milk, not subjected to any heat treatment, a fishy smell may result through the slight acidity of the milk and contact with metals accelarating the hydrolysis of lecithin.

CHAPTER XVII

CHEESE AND MISCELLANEOUS MILK PRODUCTS

Rennin.—Rennin is an enzyme present in the stomach of young calves. It is extracted from dried calf's stomach, with salt solution. The extract is usually associated with varying quantities of pepsin. Pepsin is removed by various processes and the purified rennin is called 'rennet'. Pure rennet can coagulate 2·4 million times its weight of milk and is used in the manufacture of cheese. It is most active at a temperature of about 105° F., in a slight acid medium.

Cheese making.—Milk is coagulated by ripening it with lactic organisms or by the addition of rennet or by both together. Curd is formed by the clotting of casein, which encloses the fat and the insoluble salts in milk. The curd serum, called 'whey', contains lactose, lactic acid, albumin, globulin and traces of fat. When the curd sets firm, it is cut into cubes of about ¾ inch in size with special cheese knives. One kind of cheese knife has a number of blades fixed parallel to each other, at equal distances, in an end-on position with reference to the handle. The other has the blades in a broad-side on position. The former is used for making vertical cuts and the latter for making horizontal cuts in the curd, for separating it into cubes.

The curd cubes are cooked at a temperature of 95° to 105° F. During cooking, they shrink in size and expel the curd serum or whey held by them. They are stirred gently in the beginning and fairly well later, after the cubes get hardened. The curd cubes that float at the beginning sink in the whey on completion of cooking. If properly cooked curd is rubbed between the fingers within a bowl of water, it does not make the water turbid or milky.

The cooked curd is kept heaped up on boards to drain the whey and to develop the required acidity. The cubes are then milled, shredded, mixed with salt and loaded in

special presses to expel the remaining whey, held by the curd. Cheese may be consumed fresh or after ripening in storage for varying periods. It loses moisture during storage and particularly from the surface layers and a hard rind develops during the course of a few days. It is then given a protective coat of wax, for preventing further loss of moisture, or alternatively, the atmospheric moisture in the storage room is raised suitably. During ripening, proteolytic enzymes, bacteria and moulds act on the material and there is an increase of acidity. The proteins are converted to various soluble nitrogenous compounds, which impart their characteristic flavour and taste to cheese. The type of ripening that takes place is influenced by (1) the original acidity of the material, (2) the bacteria and mould present, (3) the salt added, (4) the humidity of the storage room, (5) the moisture left in the cheese, (6) the aeration provided and (7) the storage temperature. These are suitably regulated in big cheese factories, and the type and quality of cheese desired are produced. Conditions of ripening are not under such effective control in the household and in small cheese factories and so, the cheese produced there is not of uniform quality.

There are many types of cheese, but they can be broadly classified as soft and hard cheeses, based on their moisture content. Soft cheese contains about 70 per cent. of moisture and is consumed in the fresh state. Hard cheese contains 35 to 45 per cent. of moisture and is used after varying periods of storage and curing. The manufacture of a few important types of cheese will now be considered.

Cottage cheese.—This is made at home with skim-milk, milk or milk enriched with cream, according to preference. The clotting is done with lactic starter or rennet or both, The curd is cut into cubes and cooked in a water jacketed vessel, with the temperature at 96° F., when the cooking starts. The temperature is then raised gradually by 1° F. every five minutes, till a temperature of 100° F. is reached.

The curd cubes shrink to two-thirds the original size during cooking. Prolonged cooking gives a tough, rubbery product. The whey is drained after cooking and the curd is washed in three changes of cold water and piled on a board to get drained. If preferred, cream may now be added up to half the weight of the curd. Salting is done at one ounce for every 5 lb. of curd. It is then passed through moulds and packed. This cheese is soft with a mild acid taste and is consumed fresh, within a few days of making.

Swiss cheese.—This is made from whole milk. A pure culture of *Lactobacillus bulgaricus* is inoculated to ripen the milk and rennet is also added for clotting. The curd is cut, cooked, drained and finally pressed to expel the whey. It is then milled, salted, passed through suitable moulds and cured in storage for about 6 months. Smooth holes, about ½ inch in diameter, develop in the cheese, by the production of gases resulting from the activity of *Bacterium acidi propionci.*

Roquefort cheese.—This was originally made in France with sheep's milk, though it is now made with cow's milk. The mould *Penicillium roqueforti* is grown on bread and is interspersed in the cheese curd when the latter is put in the mould. The material is pierced with long iron needles, to provide aeration for facilitating the growth and development of the mould. The mould is bluish green in colour and gives a mottled appearance to cheese, with blue veins running in different directions in the cheese mass.

The value of cheese.—Cheese is a concentrated milk product that could be kept in storage for a long time and used for consumption when required. It is rich in proteins and fat and is easily digested when consumed with other foods. It has a pronounced sharp flavour and taste, which is not relished till a taste for it is acquired. One hundred pounds of milk produce 13 lb. of soft cheese or 10 lb. of hard cheese. The following percentage composition of cheese gives an idea of its high food value.

Percentage composition of cheese

Type of cheese	Water	Protein	Fat	Ash
Cottage cheese ..	69·8	23·2	1·0	1·9
Cream cheese ..	38·4	13–16	43–48	0·5–1·25
Swiss cheese ..	33·8	29·0	30·5	4·5
Roquefort cheese ..	38·2	21·7	32·0	5·9

Ice-cream.—This is a frozen milk product to which are added sugar, stabilisers, colouring and flavouring materials. Nuts and fruits are added to special types of ice-cream. Cream and unsalted butter are often added to ice-cream in Western countries to make it richer and increase its food value. Ice-cream is now a factory-made product in U.S.A., where conditions of manufacture are under perfect control and the quality of ice-cream has been standardised to a large extent. The quality of the product regarding taste, palatability, flavour and consistency are maintained uniformly at a high level and consumers are offered many varieties to choose from. The factory-made ice-cream has practically ousted small scale manufacture. Ice-cream is made by small producers in South India and factory production of ice-cream has not commenced.

Ice-Cream Ingredients

Milk.—Good quality milk is the chief ingredient of ice-cream and this is enriched by the addition of cream and milk powders to raise the fat and solids-not-fat content of the product.

Sugar.—Cane sugar is used for sweetening at the level of $\frac{1}{6}$th to $\frac{1}{7}$th the weight of ice-cream.

Stabilisers.—These are added for increasing the viscosity of milk and improving its capacity to swell by enclosing air during making. The materials commonly used are gelatin, egg albumin, gums and starches. They are added at 0·5 to 1·0 per cent. of the weight of the ice-cream.

Flavouring.—Various essences like vanilla, rose, pineapple, etc., are added as flavouring agents. Standard essences are added at $\frac{1}{4}$ to $\frac{1}{2}$ of an ounce for every 10 lb. of milk.

Optional ingredients.—Fruits and various nuts are added as optional ingredients to the mixture of ice-cream ingredients, called the 'mix' or the 'ice-cream mix', just before freezing. They are sometimes layered with ice-cream at the time of serving, instead of adding to the mix.

Commercial manufacture of ice-cream.—In ice-cream factories, the liquid ingredients are poured into the pasteurising vessel, sugar and dry milk powders are added and stirred till dissolved. Gelatin is dissolved in hot water and added to the mix. The mix is then pasteurised and homogenised under pressure. Homogenisation prevents the separation of butter grains, when the ice-cream is being made. The mix is then cooled to 34° to 36° F. and held in storage for ageing. The viscosity of the mix increases with ageing and this helps in the swelling of the ice-cream during freezing. The mix is later kept agitated and frozen, when air is enfolded with the mix and a fluffy product is obtained. The increase in volume of the ice-cream may range from 60 to 100 per cent.; 100 parts of the mix by volume would give 160 to 200 parts of ice-cream. The product is now held at − 3° to − 15° F. for 6 to 15 hours for hardening and the hardened ice cream is placed on the market for sale.

Home-made ice-cream.—Ice-cream is made at home in small hand-operated freezers. The freezer consists of a closed cylindrical vessel for holding the mix, in which paddle-like scrapers are rotated with the handle provided. This is enclosed in a jacket, which holds broken pieces of ice which cause the freezing. The following is a simple formula that is used for making ice-cream at home:

1.	Rich whipped cream ..	$2\frac{1}{2}$ lb.
2.	whole milk	$2\frac{1}{2}$ lb.
3.	eggs	4
4.	sugar	1 lb.
5.	gelatin (or starch) ..	$\frac{3}{4}$ oz.

6. essence .. .. 2 to 4 teaspoons.
7. ice for freezing .. 15 lb., and
8. salt for freezing .. 1 to 2 lb.

Sugar is added to milk, 15 minutes before freezing, to facilitate its complete solution. The gelatin is soaked in cold water and heated to 140° to 160° F. till it is dissolved. If starch is used, it may be cooked and mixed. The albumin and yolk are beaten separately and added to milk. All the ingredients are mixed in the freezer.

Ice is broken into $\frac{1}{2}$ to $\frac{3}{4}$ inch cubes and placed in the ice jacket. Large pieces tend to delay freezing and produce graininess in the ice-cream. The jacket is filled with ice up to two-thirds and a layer of salt is sprinkled on the top. The addition of salt lowers the temperature of the freezing mixture to − 15° F. The mix is chilled for about 20 minutes, when the temperature drops down to 50° F. The handle of the freezer is turned slowly during chilling. If the handle is turned at normal speed, fat particles coalesce and butter granules separate. Later, when the mix is solidifying, the handle is rotated slowly again, when the dasher scrapes the frozen material from the sides of the freezer and mixes it with the unfrozen milk inside; a certain amount of air is also enfolded now in the mix. After the mix freezes, the handle does not turn easily. The dasher is then removed, the ice-cream is patted lightly for producing an even surface and the vessel is closed. The jacket is then filled with ice and salt, and the frozen ice-cream is allowed to stand for about 2 hours for hardening.

Over-run.—The frozen ice-cream is 60 to 100 per cent. more in volume than the mix and this is referred to as 'over-run'.

Subsidiary Milk Products

Casein.—Milk a valuable food product and all the milk produced should as far as possible be used for human consumption. In dairy butter-producing areas, considerable quantities of skim-milk become available as a by-product, which is largely used for feeding pigs and poultry. Poultrying

and pig raising are important subsidiary industries associated with dairying. The production of skim-milk powders has been developed in recent years and they are exported to countries, where milk is in short production. Skim-milk is also used for the manufacture of casein.

Manufacture of casein.—Skim-milk is passed through cream separators for removing the residual fat and reducing the fat content to the utmost. Lactic starter is then added and the skim-milk is allowed to ripen fully. The curd that forms is cut with cheese knives and cooked at a low temperature for the separation of whey. The whey is drained and the curd is washed in three changes of water for the removal of lactose and lactic acid. The water is drained and the curd is shredded and dried artificially at 130° F. till the moisture content is reduced to about 5 per cent. The dried material is pure casein. It is ground and packed for sale.

The curdling of skim-milk can be brought about quickly by the addition of whey drained from a previous batch, lactic acid, sulphuric acid or other acids. Hydrochloric acid is commonly preferred to others for this purpose.

High grade casein can be produced only from skim-milk of excellent quality. Dirt, fat and large number of bacteria in skim-milk affect the quality of the casein produced. Dirt gives rise to a discoloured patchy product and fat, to brown specks. Proteolytic bacteria modify the chemical composition of casein during storage and lower its value.

Commercial uses of casein.—Casein is used for sizing paper, for the manufacture of glue, plastics, paints, spreader in spray mixtures, etc. Casein glue is very resistant to water and binds materials extremely well. It is in use in the plywood industry, particularly where quality plywood is made. The same sticky property makes it very valuable for use in spray mixtures. The sprayed chemicals stick fast to the leaves and branches of plants.

Lactose.—This sugar is present in milk as a solution and passes on to whey during the manufacture of cheese. The whey is first passed through cream separators for the

removal of the residual fat. It is then heated for coagulating the albumin and globulin present. They are separated and the remaining liquid is concentrated and cooled, when lactose crystallises out. It is separated by centrifuging and dried.

Lactose has a mild sweetness that does not cloy the palate like cane sugar and is used in the preparation of many medicinal pellets. It is of special value in developing suitable intestinal flora. Special types of candy are also made with lactose.

Condensed milk.—Milk is bulky for transport over long distances and it does not also keep well on storage. It is not therefore possible to hold it for long periods or to transport it over long distances. Methods of condensing milk were developed towards the close of the nineteenth century and condensed milk was packed in hermetically sealed tins. Condensed milk, without any added sugar, is called 'plain condensed milk' or 'evaporated milk'. Sugar is sometimes added to milk while condensing and 'sweetened condensed milk' is also produced. These are diluted with water to the extent required, at the time of use.

When milk is heated in vacuum pans, it boils at 130° F. and gets less bulky, by loss of water by evaporation. Milk is not appreciably affected by a temperature of 130° F. and the condensed milk so produced has most of the properties of fresh liquid milk. It has, however, a light caramelised odour, which is not very objectionable. The average percentage composition of condensed milk is given below:

Product	Water	Fat	Protein	Lactose	Ash	Sucrose
Sweetened condensed milk	26·8	9·0	7·8	12·9	2·0	41·5
Evaporated whole milk	73·5	8·3	6·5	10·0	1·6	..

Milk powders.—The production of milk powders is a further stage in the reduction of bulk of the milk. The milk powders contain less than 5 per cent. of moisture.

They are of small bulk and are easily and conveniently handled in transport. They are mixed with water when required. The reconstituted milk obtained thus is almost as good as whole milk. Milk powders are made by three different methods, namely dough drying, film drying and spray drying.

Dough drying.—Milk is heated in vaccum pans till it becomes doughy in consistency by loss of moisture. It is then spread in thin layers in drying chambers, till the moisture is reduced to 3 to 5 per cent. The dried dough is ground fine and packaged. This milk powder is only 50 to 60 per cent. suspendable in water and considerable sediment is left below. It is largely used for feeding pigs and poultry. Dough drying has been replaced now, by better methods of production, which give satisfactory powders, almost completely suspendable in water.

Film or drum drying.—Milk is sprayed on hollow cylindrical rotating drums, kept hot with steam circulating inside. The moisture in the milk is evaporated and thin films of dry milk gather on the surface. These are scraped, powdered and packed. This film dried powder is not very much different from the dough dried milk powder.

When the spraying drums are, however, enclosed in vacuum, milk is dried at a lower temperature. The powder produced in the vacuum drying process is 99 per cent. miscible in water and the reconstituted milk is nearly as good as fresh milk.

Spray drying.—Milk is sprayed as a fine mist into hot chambers. The moisture is abstracted from the milk by the hot air and milk powder settles down as fine particles on the floor, which are gathered, packed in tins and hermetically sealed. Spray milk powder keeps well for long periods, mixes with water readily and is popular with consumers. The reconstituted milk obtained from this powder is very much like fresh milk. Buttermilk and skim-milk are also made into powders similarly. Skim-milk powders are used largely by confectioners and ice-cream manufacturers. They

are also used for producing reconstituted milk with the addition of water and vegetable oils, fortified with vitamins A and D.

Reconstituted milk.—To meet the ever-increasing demand for milk in Madras, the Government is operating a reconstituting milk factory, producing 4 to 5 thousand pounds of reconstituted milk daily. It is made with (1) skim-milk powder 100 lb., (2) refined coconut oil 36 lb., (3) carotene in coconut oil ½ gm., and (4) water 875 lb. These are mixed, pasteurised by the holder method, homogenised, cooled to 40° F., and supplied to catering establishments and customers. Hospitals take in about 2,800 lb. daily, hotels 1,600 lb. and individual consumers 4,000 lb.

The reconstituted milk contains 3·3 per cent. of proteins, 4·5 per cent. milk sugar, 0·7 per cent. ash, 4 per cent. fat and 87·5 per cent. water, inclusive of 150 international units of vitamin A per 100 c.c. It lacks the fresh flavour associated with milk and is not popular with some people, though regular customers have no complaint and actually prefer it to bazaar milk for its cleanliness, wholesomeness and cheapness. It was sold at 4 annas a pound during 1953 in Madras, when fresh cow's milk was selling at 5 to 6 annas.

CHAPTER XVIII

INDIGENOUS MILK PRODUCTS

Types of milk products.—Temperate countries have developed butter and cheese as important milk products, as the prevailing low temperature facilitates the preparation of quality products, which keep well for long periods. Bacteria are sluggish at low temperatures and multiply only slowly, so that the changes they bring about in milk products are not very pronounced. Consequently, the milk products have a long keeping life. Such quality products can be made in India also, but not without expensive refrigeration and this makes their manufacture uneconomic. Further, they do not keep so well in a warm or hot climate, for long.

The milk products developed in India are those that can be made economically under the climatic conditions that prevail here. Among the milk products, ghee is the most important and 43·3 per cent. of the total milk in the country is estimated to be converted into ghee. It keeps well for fairly long periods, even under the high temperature that prevails. It is, however, made by the individual producers under deplorable conditions and the quality of the ghee produced is consequently very poor.

The other milk products that are made in any quantity are *dahi* (curd), *channa* (clotted milk) and *khoa* (concentrated milk paste). They are consumed in the fresh state more or less and they keep well only for a few days.

Ghee.—It is pure butter-fat obtained by melting butter and evaporating the surplus moisture. Butter is made from milk, by boiling, ripening and churning it at home. In India, it is only an intermediate product in ghee making and is seldom consumed as such.

Making butter.—Boiled milk is allowed to cool and a small quantity of buttermilk is added to it, when it is luke-warm. The milk gets ripened in 8 to 10 hours and a firm curd is produced. In certain isolated regions, as in parts

of Mysore, the curd is made out of raw unboiled milk. The curd is diluted with water to facilitate the easy separation of butter granules. The quantity of water used for dilution is variable, being about 50 per cent. by volume when the buttermilk is intended for one's own use in the house and 100 to 150 per cent., when it is intended for sale. The dilution of the curd with an equal quantity of water assists churning, promotes the aggregation of the butter-fat particles and is conducive to the maximum extraction of fat. Most of the curd acid and bacteria pass to the buttermilk at this dilution. A greater dilution is not of any special advantage; the buttermilk gets too dilute and its value is lowered.

The churning is done in earthenware or tinned brass vessels. A wooden paddle is used for agitating the curd. The paddle has a long stem, for being held in position, with either two suitable iron rings or loops made with rope. A thin rope is passed round and round the stem. The two free ends of the rope are pulled alternately, for rotating the paddle clockwise and anticlockwise. The portion of the paddle used for agitating the curd is considerably thickened, 4 to 6 inches across, and is deeply corrugated on the surface, for facilitating the proper agitation of the curd.

As the diluted curd is churned, it is broken and agitated violently, bringing about collision between the fat particles. They coalesce consequently and butter granules are formed gradually. When the granules are of sufficient size, the churning is stopped and the butter grains are gathered with the hand. The surplus buttermilk is allowed to drain through the fingers for a while and the butter grains are given a slight rotary motion and bulked. The butter obtained each day in the ordinary household is too small to be melted into ghee immediately. It is kept in earthenware, either alone or with a little water or buttermilk and is melted into ghee or sold to ghee merchants, about once a week. The merchants collect the butter from several small producers and keep it in tinware. The butter that is left unsold with them gets very sour in about

a week and takes an off-odour, when it is melted for sale as ghee.

Melting butter.—Butter is melted in wide mouthed vessels and boiled vigorously in the beginning to drive out the moisture. The boiling liquid composed of butter-fat and buttermilk is turbid and a crackling sound is produced when moisture escapes from the melted fat. When most of the moisture has escaped, the boiling liquid begins to clear and the crackling sound gets less. The fire is now reduced and the liquid is heated gently. The casein and curd particles held by the butter separate and settle down as granules, when the liquid clears and loses its turbidity. The granules are creamy in colour in the beginning, when the temperature of the boiling liquid is about 108° C. (226° F.). As the boiling proceeds, the moisture gets reduced further and the temperature of the liquid rises. The casein granules get browned at about 115° C. (239° F.). This would appear to be the best stage for stopping the boiling. The temperature at which boiling is stopped ranges from 110° to 140° C. (230° to 284° F.) and is regulated by the demand of the consuming market. As the temperature of the boiling is raised, the casein granules get charred and the ghee takes a caramelised odour. There is also break-down of the fats at the higher temperatures and free fatty acids are produced. These acids also contribute to the flavour of the resulting ghee. Ghee boiled at a low temperature is bland and does not possess the sharp and strong flavour associated with ghee boiled at a high temperature and this is a matter of personal taste. Ghee boiled at a temperature of about 115° C. has a low acidity and keeps well in storage and production of ghee with a low acidity should be the objective, with reference to the keeping life of the ghee.

A small bunch of *murungai* (*Moringa oleifera*) or curry leaves (*Murraya koenigii*) dipped in buttermilk is added to the boiling ghee, immediately on removal of the ghee from the fire. There is vigorous crackling as the leaves get fried in the boiling ghee. After it cools down, it is decanted

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and stored in earthenware by the small producers and in tins by ghee merchants.

Quality of ghee.—Ghee is a nutritious, wholesome and palatable milk product of great value, appreciated by all people. When it is made properly and kept under suitable storage, it keeps in good condition for over six months, with but a slight loss of freshness and flavour. After an year, it takes an off-odour and is spoilt. But even fresh market ghee is very poor in quality, wanting in its characteristic good flavour and aroma and smelling badly instead. About 3·8 lakhs tons of ghee, valued at 193 crores of rupees, are estimated to be produced in India, annually. Most of it is badly made and a large part is deliberately adulterated with various animal fats and vegetable oils. Good ghee can be as easily made as bad or indifferent ghee and at no greater cost or expenditure of energy. A little care and attention at the several stages of making is all that is needed to improve the quality of the ghee. The production of ghee is a major industry and requires to be reformed in the larger interests of the vast number of producers and consumers.

Causes of spoilage of ghee.—A number of factors operating from the time of milking to the boiling and storage of ghee are responsible for its spoilage. Milk is generally drawn in brass or tin vessels and traces of brass and iron pass on to milk. These act as catalysts and promote the development of acidity in ghee and the oxidation of fats, particularly the unsaturated ones like the olein. Secondly, bacterial and fungal organisms get into milk, after it is drawn, in various ways. These affect the keeping quality of the milk and the various products made of it. The milk should be boiled preferably for 10 minutes, as soon as possible after milking, to destroy the organisms present and kept covered to prevent the entry of fresh organisms. Milk is made into curd in certain areas, without any heat treatment or boiling and this is an undesirable practice. The curd made with raw milk varies in quality from day to day, as the type of fermentation during ripening is not then under control.

The changes taking place in milk during ripening are dependent on the types of organisms in the starter and the milk. When the milk is boiled and the organisms therein are destroyed, the bacteria introduced by the starter develop without any competition from other organisms and the ripened milk has the same identical qualities as the starter material. By the use of proper starters, curd with uniform quality can always be produced. The formation of gases in the curd, off-flavours and its separation into layers, a solid layer at the top and a liquid layer at the bottom, are indications that the starter material is not of the right type. Such starters should be discarded and substituted by suitable, fresh starters.

When butter is made, the butter granules are gathered and bulked enclosing varying quantities of buttermilk. During storage, the acidity of buttermilk increases and there is decomposition of protein leading to putrefaction. When butter is melted, the acidity of the buttermilk passes on to the butter-fat. In view of this, the butter granules that form on churning should be gathered and floated in two changes of water to free the butter granules of the adhering buttermilk and acids. Rangappa and Achayya[18] suggest the removal of buttermilk from the churning vessel with either the use of a rubber syphon tube or by providing a tap at the bottom of the churning vessel. The butter granules are left in the churning vessel. Water equal to the buttermilk removed is added and churned lightly, and the butter is gathered in the usual manner from the wash water, instead of from the buttermilk. The washed butter has a low acidity and good storage life, comparable to that of dairy butter.

Since the acidity of butter increases during storage, it should be melted as soon as possible after making and in any case within three days, so as to keep the acidity in the resulting ghee at a low level. Storing butter for long periods is the most potent cause leading to the increase of acidity and the production of bad quality ghee. Even badly made butter enclosing considerable buttermilk gives rise to ghee of good quality, when it is immediately melted. The changes

taking place in butter during storage vitally affect the quality of the ghee produced. The longer the storage of butter, the greater is the deterioration of both butter and ghee. Butter keeps best, when kept immersed in buttermilk, changed everyday by fresh buttermilk. There is then the least change; the development of acidity is low and there is not much visible change in the flavour and aroma of butter.

Earthenware are commonly used for keeping milk and milk products in the ordinary household. They are porous in nature and harbour bacteria and other organisms, unless special care is taken to sterilise them properly. Tinned brass and aluminium vessels may be used instead.

Other methods of making ghee.—In parts of Guzerat and Baroda, the butter is melted and brought to the boil, when the fat separates out from the butter serum. The butter serum is made up of buttermilk, as the butter granules are not washed before bulking. The butter-melt is allowed to cool and solidify and the buttermilk is drained. The solid fat portion contains a little moisture, which is removed by boiling in the usual manner. Draining the buttermilk before boiling the ghee, which may be called the 'draining method', is an improvement over the ordinary method of boiling the ghee directly. The acids of the buttermilk are removed by draining and they do not pass on to ghee during boiling. This method helps to reduce the acidity of the resulting ghee by about 50 per cent.

It has been suggested by French[7] that cream may be diluted with water equal to 50 per cent. of the original volume of the milk, passed through the separator again and the re-separated cream boiled to ghee straightaway. The ghee so produced has very good keeping qualities, but has nearly the same flavour as butter and is devoid of the characteristic flavour of ghee. An elaboration of the method combining ripening of the cream may possibly be suitable for large ghee-producing concerns, but not for the small producer.

One of the ghee-making concerns at Tiruppur (Coimbatore district) fitted a double jacketed iron pan for boiling

ghee, on advice from the Indian Dairy Institute, Bangalore. The outer jacket of iron is in contact with the fire and there is an air layer between it and the ghee boiling pan. The pan is provided with a stop-cock and tap at the bottom. Butter is melted and held at 80° C. for an hour, when the butter-melt separates into three layers, with the scum at the top, a middle layer of fat and a layer of buttermilk at the bottom. The buttermilk is drained through the tap and the ghee is then boiled straightaway. The boiling is stopped at 112° to 115° C. The ghee produced has a lower acidity, but because of lack of the flavour desired by consumers, the product does not meet with the approval of the trade. The double jacketed pan saves fuel and the concern prefers to drain the old buttermilk that has a strong acid smell and substitute it by an equal quantity of fresh buttermilk, for the production of ghee that is acceptable to the consumers. The substitution of the old buttermilk by the fresh one gives a product that is much better than ghee made by the boiling method.

The range of acidity of milk and of the several intermediary products in the manufacture of ghee are given below:—

Product	Percentage acidity as lactic acid
Fresh milk	0·12 to 0·16
Curd	0·8 to 1·4
Butter	0·17 to 0·22
Ghee obtained by direct boiling	0·05 to 0·10
Ghee obtained by the draining method	0·02 to 0·05
Bazaar ghee	0·5 to 3·5

The acidity of butter is a fifth or sixth of that of the curd. The acidity of ghee is about half that of butter where the direct boiling method is adopted and a fourth to a fifth

where the draining method obtains. Ghee with a low acidity kept in porcelain-ware or tinned or aluminium vessels, with little or no air-gap at the top and a tight lid on, keeps well for over 6 months. There is some off-flavour only after an year's storage.

The bazaar ghee is normally a high acid product, with an acidity range of 0·5 to 3·5 per cent. or more. Even where it appears to be good, it does not keep well for over a week. Bad quality bazaar ghee is considerably improved by boiling it with ripe banana slices at one fruit, roughly one ounce of pulp, per pound of ghee. The ghee is boiled till the slices get brown. As the ghee cools, the banana slices turn black and the ghee can then be filtered through muslin cloth. The putrid bad smell of the ghee gives place to a faint ghee flavour after boiling. The acidity of the ghee is reduced and a passable product is obtained.

Good ghee can be produced by observing the following elementary principles:—

(1) Tinned brass or aluminium vessels should be used for handling milk and milk products. Earthenware is very unsuitable.

(2) Milk should be boiled for 5 to 10 minutes, as soon as possible after milking.

(3) Good starter with a clean acid smell alone should be used, for ripening milk.

(4) Butter granules should be washed free of buttermilk, bulked and kept submerged in buttermilk during storage, changing the buttermilk every day.

(5) Butter should be boiled into ghee as soon as possible after making and in any case within 3 days, using the draining method preferably.

(6) The boiling of the ghee should be stopped, when the curd particles start browning and the ghee should be filtered through muslin, after cooling.

(7) Ghee should be kept in tinned brass or aluminium containers filled to the top, with no air at the top and closed with a tight fitting lid.

(8) Exposure of ghee to light, heat and moisture, and contact with metals like copper, brass, iron, zinc, etc., should be avoided to the utmost.

Changes Taking Place in Ghee During Storage

(1) *Development of acidity.*—It has been shown that ghee with a low initial acidity could be produced easily. The household method of making butter enfolds buttermilk and the acidity of buttermilk increases with storage. When the butter is melted into ghee, the acidity of the buttermilk passes on to the fat and contributes to the initial acidity of the ghee. These acids act as catalysts and accelerate the development of further acidity in ghee. Other causative factors promoting the development of acidity are exposure of the ghee to heat, light, moisture, air and heavy metals.

(2) *Tallowiness.*—When ghee is stored for some time, the granularity of the material gives place to a pasty greasiness and a tallowy smell develops. This is caused by the oxidation of olein. The oxidation of the natural fats and oils is kept in check in the early stages by 'anti-oxidants' present, which protect the fats and inihibit oxidation. Vitamins and carotene are known to act as anti-oxidants to an extent. In course of time, the anti-oxidants in ghee are destroyed and the oxidation of the fats commences. Further oxidation proceeds at a rapid rate. Where ghee is kept in large containers, the top layers may be affected and get greasy and tallowy, while the bottom layers may be in excellent condition with the original granularity and flavour intact. Earthenware used for storing ghee facilitates oxidation of ghee and production of tallowiness.

(3) *Rancidity.*—The moisture in butter tends to hydrolyse the fats and liberate the free fatty acids, like butyric and caproic acids, which have an unpleasant and pungent smell. This is referred to as rancidity. Even high acidity is not so objectionable as rancidity, however slight. Rancidity in ghee is not common, as moisture present in ghee is low. If ghee is made out of rancid butter, the rancidity

passes on from the butter to the ghee and is not to be shaken off by the heat treatment that converts butter into ghee.

Curd.—It has been estimated that 9·1 per cent.[20] of the total quantity of milk produced in the country is converted to curd. This is used for consumption with rice in South India and with wheat preparations in North India. Curd has the same nutritive value as milk. Milk is fermented with lactic organisms and curd is the resulting product of fermentation. A fifth of the lactose in milk is converted to lactic acid and other nutritive elements remain intact. In the household, the top portion of the curd is removed for making butter and the rest is consumed as such.

When a suitable lactic culture is added to warm milk, that is, milk boiled and cooled to about 100° to 110° F., the resulting curd is firm. It has a glossy surface and a clean, sharp, but mild acid flavour and an aggreeable odour. Defects in the curd are caused by the presence of undesirable organisms in the starter. A dull matty surface on the curd is indicative of the incursion of moulds. If the utensils used in handling milk are sterilised properly and boiled milk kept under cover is inoculated with a suitable starter, the above defects can be avoided. The curd prepared for direct consumption is usually made with care and is generally free of defects.

Buttermilk.—Curd is also produced for making butter, but it is not so carefully made, as for direct consumption. When curd is churned and the butter is separated, the buttermilk left behind is used for consumption either as a drink or mixed with rice. The quality of the buttermilk is very variable, depending upon the care bestowed in its preparation. Raw milk is used for ripening in certain regions. Porous earthenware, which harbour micro-organisms and which are difficult to sterilise, are used for keeping buttermilk. The starter used for ripening is often of indifferent quality. The extent of dilution practised is also variable. All these are responsible for the variations found in the buttermilk.

Buttermilk made from cream is used for feeding livestock in Western countries and that made directly from milk is used as a valuable human food in India. The former is poor in feeding value, being only diluted cream deprived of its fat. The latter is much richer because it contains all the ingredients present in milk, except fat.

Skim-milk is also ripened and diluted for use as buttermilk, but it has not got the same appeal to the palate as that made from whole milk. The protein colloids enveloping the fat particles are released into the buttermilk during churning and these give a stability to the suspension of casein in buttermilk. The buttermilk is therefore homogeneous and this gives a feeling of body to it! The protein colloids associated with fat pass on to cream during the separation of milk and are not present in skim-milk. The skim-milk gives therefore a buttermilk, which is not homogeneous. It has a low viscosity, lacks body and is not so agreeable to the palate as the one made with whole milk or cream.

Khoa.—This is one of the important milk products of India. About 4 per cent. of the total milk produced in the country is estimated to be used for making *khoa*.[20] It is concentrated milk. Milk is boiled briskly in open mouthed, round bottomed iron pans, in small quantities of 4 to 5 lb. The boiling milk is stirred constantly with an iron scraper, to prevent the solids sticking to the pan and getting charred. The milk turns into a semi-solid mass in about 15 minutes. The soft mass is spread out thinly with the scraper and collected into a mass repeatedly, till the mass is of a soft buttery consistency. The soft *khoa* is removed from the fire and flattened out to facilitate cooling. The plastic material gets firm on cooling.

Khoa is white in colour, plastic and lightly sweet to the taste. If the milk is not boiled briskly, the resulting *khoa* is dark in colour; it is also gritty to the feel, due to the crystallisation of lactose. It keeps well for 4 to 5 days. When sweetened with sugar, it keeps well for over 2 months. It is commonly used as a base for the preparation of many Indian sweets and is seldom consumed as such.

Channa.—Clotted milk or *channa* is a speciality of Bengal, where it is commonly used for making many sweets. Milk is boiled in small lots of about 2 lb. The juice of one lime fruit or 20 to 25 grams of citric acid dissolved in water is sprinkled over the boiling milk for coagulating it. The supernatant whey is drained and the residue is allowed to drain through a muslin cloth, in which the clotted material is kept suspended. This product is called '*channa*' and is used immediately for making sweets, as it gets sour on keeping even for a day.

Composition of milk products.—The following statement furnishes the composition of the milk and milk products, that have been considered already.

Percentage composition of some milk products

Name of product	Water	Total solids	Fat	Lactose	Protein	Ash	Cane sugar
1	2	3	4	5	6	7	8
Khoa	30	70	36	30	18	5·0	Cols. 4 to 7 on a dry basis
Channa	20	35–50	25–35	2·0–2·5	15–20	0·3–0·4	
Butter	15	87	83·5	0·2	0·3	0·2–0·5	
Cheese hard ..	33	..	32	1·3	27·2	6·5	..
Cheese soft ..	42	..	30	1·4	20·6	6·0	..
Condensed whole milk:							
Sweetened ..	26	..	9	12·3	8·6	1·9	42·8
Unsweetened ..	68·2	..	9	12·3	8·6	1·9	..
Condensed skim-milk:							
Sweetened ..	27·0	..	0·3	14·4	10·2	2·3	45·8
Unsweetened ..	77·7	..	0·2	12·0	8·3	1·8	..
Dried whole milk ..	3	..	26·2	38·4	26·4	6·0	..
Dried skim-milk ..	3	..	0·9	51·6	36·3	8·2	
							Solids-not-fat
*European cow's milk	87·32	12·68	3·75	4·75	3·40	0·75	8·93
*Indian cow's milk ..	85·28	14·72	5·67	4·69	3·69	0·76	9·05
*Indian buffalo's milk	81·76	18·26	8·11	5·00	4·33	0·82	10·15
*Skim-milk ..	90·40	9·60	0·12	5·21	3·54	0·73	9·48
*Thin cream ..	72·40	27·60	20·0	4·20	2·80	0·60	7·60
*Thick cream ..	58·80	41·20	35·0	3·40	2·30	0·50	6·20

Source: Davies, W. L., *Indian Indigenous Milk Products*, 1940, pp. 7, 23, 67 and 89.

Note.—Items marked with an asterisk are from miscellaneous sources.

CHAPTER XIX

SIMPLE DAIRY TESTS

Sampling milk.—Milk is purchased by large dairies and creameries in considerable quantities and a periodical check-up of the quality of the milk delivered is commonly made. The quality of milk is judged by making certain rapid tests, taking samples for the estimation of specific gravity, fat content and acidity of milk. It is obviously necessary, that the samples should be truly and really representative of the milk delivered. The fat in milk tends to rise to the surface, even when the milk is kept undisturbed for a short time, on account of the difference in densities of the various constituents of milk. The milk has therefore to be well mixed, before the sample is drawn. When the milk is small in quantity, it may be poured from one vessel to another 3 or 4 times to effect a thorough mixing of the milk. Large quantities of milk are mixed thoroughly by working aluminium plungers up and down several times in the milk churn. The plunger is made of a perforated circular disk, with a heavy rod fixed in the centre to serve as handle, just like the Horlick's mixer used for mixing malted milk foods. A small sample of the milk is drawn for testing, after the milk has been mixed properly.

Composite samples.—When a number of churns are delivered by an individual, a composite sample is taken by drawing a small sample from each of the several churns delivered, in proportion to the quantity of milk in each churn. Thus, if 3 churns containing 10, 15 and 20 gallons of milk are to be sampled, 2, 3 and 4 ounce samples taken respectively from the 3 churns and mixed together will be a representative composite sample, of all the three churns of milk.

In large concerns, milk testing is done once a week with composite samples of the milk delivered during the week by the several customers, as daily testing involves considerable labour. For this purpose, half to one ounce sample for each gallon of milk delivered is taken and kept preserved

in labelled bottles and they are tested at the end of the week. A small quantity of potassium bichromate is added to give the milk a light yellow colour and serve as a preservative, when it is intended to test fat only. If solids-not-fat are also proposed to be tested, formalin is added to the sample at 1 c.c. per quart of the sample.

The specific gravity of milk.—This varies widely and ranges from 1·020 to 1·036 normally. The average specific gravity of composite samples of milk may range from 1·028 to 1·032 and a specific gravity lower than 1·028 gives room for suspecting that the milk may be adulterated with water. The specific gravity of each of the various milk constituents is as follows: fat 0·93, albumin and globulin 1·346, casein 1·310, lactose 1·666 and minerals 4·210. The above constituents of milk can be divided into two groups, namely fats and solids-not-fat (S.N.F.). Fat has a specific gravity of less than 1·000, the specific gravity of water. The other constituents have higher specific gravities. Addition of water lowers the specific gravity of milk. The determination of the specific gravity of milk is not very helpful in detecting the adulteration of milk. It is however used for the determination of the total solids in milk and solids-not-fat. Gravimetric determination of solids in milk made by evaporating milk gives accurate results, but it takes considerable time and the specific gravity of milk is determined in dairies usually by using the lactometer. This does not give accurate results like gravimetric determinations, but is satisfactory enough for practical purposes.

The Quevenne lactometer is a hydrometer specially calibrated for the determination of the specific gravity of milk. Graduations of 15 to 40 are marked on the hydrometer and correspond to specific gravities of 1·015 to 1·040, at a temperature of 60° F. The lactometer is also provided with a built-in thermometer for taking the temperature of the milk, at the time of the observation. Any reading made with the lactometer requires to be corrected to the standard temperature of 60° F. for the purposes of comparison. The correc-

tion factor found suitable for use in European countries is 0·1, which is added to the lactometer reading for every degree rise of temperature over 60° F. Thus, if the reading of the lactometer is 32 at 70° F., the correction factor would be (70—60)×0·1 or 1·0 and the reading corrected for 60° F. would be 33 and the specific gravity would be 1·033. The same sample of milk would give lactometer readings of 34, 33, and 32 at 50°, 60°, and 70° F. respectively.

The factor used in European countries for correcting the lactometer readings taken at various temperatures is not suitable for use under Indian conditions. The fat and S.N.F. content of milk vary only within narrow limits in European countries, while they vary widely here. For example, in India, the fat content of cow's milk ranges from 3 to 5·5 and of buffalo's milk from 6 to 8 per cent. Further, the correction factor of 0·1 is intended for correcting readings from 50° to 80° F. only. The wide variations in the fat and S.N.F. content of Indian milk and the high temperature of the tropics affect the applicability of a single constant correction factor. Kothavalla, Z. R., Ananthakrishnan, C. P. and Paul, T. M., determined at Bangalore the following additions that have to be made for correcting to the standard of 60° F., the lactometer readings of milk, with 3 to 8 per cent. of fat, at temperatures from 50° to 110° F.

Zal-Krishnan table for correction of lactometer readings

(Additions to be made to the lactometer readings to correct the readings to 60° F.)

Temperature in degrees Fahrenheit	Per cent. fat					
	3	4	5	6	7	8
50	−1·3	−1·5	−1·6	−1·6	−1·9	−2·0
60	..	..	..	..	..	..
70	1·5	1·5	1·9	1·9	2·0	2·0
80	3·2	3·4	3·9	3·9	4·1	4·1
90	5·1	5·3	5·8	6·0	6·2	6·3
100	7·2	7·5	7·9	8·4	8·8	9·1
110	9·4	9·8	10·2	10·6	10·8	11·2

Source: *Indian Journal of Veterinary Science and Animal Husbandry*, 1949, **19**, 1, 73.

Testing fat.—The fat content of milk can be accurately determined by extraction with ether in the laboratory, but this method is not so convenient for making rapid tests on a number of samples in the dairy. A number of methods of testing the fat content of milk in a rapid manner have been devised, of which two have become standard tests. The Babcock test devised by Dr. S. M. Babcock of Wisconsin Experiment Station is largely in use in U.S.A. The Gerber test, devised by Dr. N. Gerber, a Swiss chemist, is in common use in European countries. Both the tests use concentrated sulphuric acid for dissolving the solids-not-fat of milk and facilitating the easy separation of fat, which is read off directly from the special test bottles used for the purpose. Both the tests are accurate enough for practical purposes in the dairy and give readings, which do not deviate by more than 0·05 per cent. of fat, from the exact determinations made by the extraction of fat with ether.

The Gerber test.—The fat testing bottle is of a special design and is called the 'butyrometer'. It has a bulbous body for holding the milk and the reagents used for the test. The body is continuous with a flattened steam, calibrated to read off the fat percentage directly. One end of the tube is sealed. The other end near the graduated stem is open and the mouth is closed with a rubber stopper when needed.

Ten c.c. of concentrated sulphuric acid, with a specific gravity of 1·820 to 1·825, is measured into the butyrometer with a pipette or preferably with a special separating funnel, provided with double stop-cocks for delivering 10 c.c. of acid automatically. Milk is next measured with a 11 c.c. special pipette and added to form a layer over the acid in the butyrometer. Finally 1 c.c. of amyl alcohol of 0·815 to 0·818 specific gravity is added to the milk and the mouth of the butyrometer is closed with the rubber stopper. The butyrometer is shaken to mix the contents and dissolve completely the curd formed with the casein in the milk. The butyrometer is inverted and the stopper is adjusted to bring the liquid into the graduated stem.

The butyrometer is next placed in the special Gerber centrifuging machine in pairs, one in each of the two opposite pockets. Where an odd number of butyrometers have to be centrifuged, a dummy tube filled with water is added for balancing the odd butyrometer in the centrifuge. The machine is rotated at the rate specified by the manufacturers for 4 minutes. The butyrometers are next held for 3 minutes in a water-bath maintained at 154° F. Keeping the butyrometers in the water-bath is not found to be absolutely necessary under South Indian conditions, as the fat could be read off even without it. The fat in the milk is collected and brought to the graduated stem of the butyrometer by centrifuging. The lower end of the fat column is brought opposite to a division of the scale for easy reading, by adjusting the rubber stopper. The fat percentage is the difference between the readings at the two ends of the fat column. The lowest point of the meniscus formed at the top by the fat column gives the correct reading. Each big division of the scale corresponds to 1 per cent. of fat and the small division to 0·1 per cent. Thus, if the bottom of the fat column is set against the big division marked 1 and the bottom of the meniscus at the top is against 5·6, the fat content is 5·6 *minus* 1 or 4·6 per cent.

The principle of the Gerber test.—(1) The sulphuric acid used for the test curdles the milk to start with and later dissolves the casein curd completely and the fat particles are released from association with the milk solids.

(2) The density of sulphuric acid is high and it increases the specific gravity of the mixed liquid in the butyrometer to about 1·5 and the difference between the specific gravity of the serum and that of fat (0·93) is increased and the fat is enabled to separate out easily.

(3) The heat developed by mixing sulphuric acid and milk reduces the viscosity of the milk serum, liquefies the fat and facilitates the complete separation of the fat from the serum.

(4) The centrifuging subjects the contents of the hydrometer to a force many times that of gravity and assists

in the complete separation of the fat from the heavier serum.

(5) The quantity and concentration of the sulphuric acid used are just sufficient for dissolving the casein, but not for charring the fat, if the several reagents are mixed in the butyrometer in the proper manner.

(6) The amyl alcohol protects the fat from being charred by the sulphuric acid used.

Determination of total solids.—This determination is made by evaporating the water present in a weighed quantity of milk and weighing the residue obtained. The residue includes proteins, lactose, ash and fat. This is too laborious for routine determinations in the dairy. The total solids are calculated instead from the specific gravity and fat content of milk, determined at the dairy by using the Richmond formula, namely $T.S. = 0{\cdot}25\ D + 1{\cdot}21\ F + 0{\cdot}14$, where T.S. represents the total solids in milk, D its specific gravity and F the percentage of fat in milk. This formula is largely used in U.S.A. It has been modified for use in Great Britain by the British Standard Institution as follows: $T.S. = 0{\cdot}25\ D + 1{\cdot}21\ F + 0{\cdot}66$. The figures for total solids calculated by the use of the above two formulæ were found to be lower than those obtained by gravimetric determinations made at the Indian Dairy Institute, Bangalore. The milk from several breeds—the Sindhis, the Cross-breds, the Sahiwals, the Girs, the Tharparkars and the Murrah buffaloes—was used in these determinations. The figures for total solids determined by gravimetric methods were on the average higher by 0·22 than the figures obtained by the use of the B.S.I. formula (unpublished communication from the Director of the Institute). The following formula may be taken as being suitable for use under South Indian conditions: $T.S. = 0{\cdot}25\ D + 1{\cdot}21\ F + 0{\cdot}88$, where T.S. is the total solids in milk, D its specific gravity at 60° F. and F is the percentage of fat in the milk.

Determination of acidity of milk.—The average acidity of fresh milk, expressed as lactic acid ranges from 0·12 to

0·16. The acidity of milk increases on keeping, as a result of bacterial activity, particularly of the lactic organisms. When the acidity of milk is over 0·26 per cent., it is likely to get clotted on boiling and factories handling milk reject samples that have acidities higher than 0·19 per cent.

The acidity of milk is determined in the dairy by pipetting 10 c.c. of milk into a porcelain dish and titrating it with N/9 caustic soda, using 1 c.c. of phenolphthalin as indicator. Each c.c. of caustic soda solution used for titration is equal to an acidity of 0·1 per cent., expressed as lactic acid.

CHAPTER XX

MILK RECORDING

Milk recording is of comparatively recent origin and the credit for initiating it goes to Denmark. The first milk recording society was formed at Vejen in Denmark in 1895 and milk recording spread rapidly in Denmark thereafter. It was taken up later by a number of countries in Europe, America and by New Zealand and it has now become a standard practice in most dairying countries. The methods adopted for recording the yield of individual cows in different countries are varied. The lactation yields of milk are recorded in certain countries. Yearly records are made in certain others. The fat content of milk is also tested and recorded in some countries. The quantities of feed given to cows in terms of certain feed units are recorded in a few countries and the efficiency of milk production is evaluated from such records of milk and of feed.

It has been estimated in *Nutrition* (published by the League of Nations, 1939) that the average milk production of cows in Denmark was 2,976 lb. in 1870, 4,850 in 1900 and 7,055 in 1934, an increase of 63·3 per cent. in 30 years and 137·1 per cent. in 64 years. This is a big achievement and milk recording is being done there more extensively than in any other country.

Milk recording is done by organisations, called milk recording societies, formed for the specific purpose of recording milk and attesting to the authenticity of such records. Dairy societies formed for the development of cattle breeds, for the manufacture of butter, etc., also take up milk recording as one of their duties in certain cases. Government and official institutions also do milk recording in certain others. Most of the milk recording societies are subsidised by Governments and the association of Government with milk recording gives an authenticity and status to the milk records of these societies.

The societies employ recorders for testing the milk yields of individual cows in the herds of the members. Each recorder may be able to handle about 25 herds and test 300 to 400 cows, when testing is done once a month. The milk recorders visit the farms usually in the afternoon and record the weight of milk given by each cow during the next 24 hours. The milking is done in their presence and they take precautions to see that the weight of milk produced by each cow is correctly measured and recorded. In associations conducting the milk and fat tests, samples of milk, of each cow, and of all the milkings on the day of visit of the recorders, are taken. Fat tests may be done on the farm itself or samples may be marked and sent to a central laboratory for tests. Where feed units are recorded, the various feeds given to the individual cows on the day are weighed, for calculating the efficiency of milk production.

In some places, the records of milk yield made by the recorders is the only record of milk. In others, the owners record the daily milk yields and the recorder's test weighments are used for checking the accuracy of the recording done by the owners. The test weighments are entered in the owner's record book under signature. The owner's record is the main record and the recorder's entries are only supplementary. Where there are large differences between the daily yield records and the test yields, the latter alone are taken as correct and no value is given to the former.

The recorders also test the balances in use at the farms visited by them and give advice on the management of the dairy, sanitation and related matters, when required.

The milk yields are calculated differently in the different countries. The milk yields are furnished for the complete lactation or for predetermined periods. The length of this period differs from country to country and ranges from 200 to 365 days. Milk records may be for a period of 200 days in one country, for 305 days in another and for a year of 365 days in a third country. Where the recording is for a year, it may commence with the calendar year

or with the commencement of lactation of the animals concerned.

When milk recording is done at stated intervals, the total yields of milk and fat are calculated in different ways. The product obtained by multiplying the total yield of milk of the several periodical tests and the number of days between the tests gives the lactation yield. It is the simplest method and the most reliable.

Since the cost of testing the milk and fat production by recorders increases with the number of tests made on each cow, daily recording of yields is not practicable. The frequency of testing necessary for providing accurate yield figures has been worked out by many research workers. Intervals of 7 days, 14 days, 21 days, one month and other intervals have been studied. An yield test made once in 7 days gives results, with a maximum error of only 3 per cent. The 7-day test is therefore satisfactory and reliable, as applied to milk and fat yields.

In the 14-day intervals, the maximum errors worked out for milk yield by several people range from 2·49 to 9·5 per cent. in general and 5·3 per cent. for fat yield. It may therefore be taken that the 14 days test is good enough for practical purposes.

With 21-day intervals between recording, the maximum error does not exceed 8·1 per cent. for milk and 11·7 per-cent. for butter-fat. Though the maximum error is near about 10 per cent., such high errors are not frequent and the 21-day test also may be considered satisfactory, from a practical point of view.

Monthly tests.—The maximum error in once-a-month recording is 9·75 per cent. for milk and close to this for butter also. The high errors are not frequent here also and it may be taken that recording once a month is also satisfactory enough for practical purposes, since the maximum error is within 10 per cent. and such high errors are only a few.

Test recording milk yields at periodic intervals is subject to error, which is negligible with 7-day tests and which ranges

up to nearly 10 per cent. with 14, 21 and 30-day tests, with the high errors only in a few cases. The errors in the wide interval recordings are no doubt high, but not so high as to detract the value of recording. The records are good enough for practical purposes. Since recording milk and fat oftener than once a month increases the cost of recording unduly, it may be taken that for practical purposes, recording the production of milk and fat of individual cows once a month alone is feasible. Breeding and research institutions record the individual milk yields daily and fat yields once a week at least, if not daily.

The value of milk recording.—Milk recording has been found to be advantageous and helpful in the following ways:

(1) *Economic feeding*.—Milk record is a guide to correct feeding. It enables feeding to be regulated according to the quantity of milk given by the cows. The yields of heavy milkers can be pushed up by generous feeding and the feed given to the low producers reduced to the extent necessary. Heavy as well as under-feeding are avoided and this conduces to economy in feeding. Feeds account for over 60 per cent. of the total cost of producing milk; correct feeding avoids wasteful expenditure and increases the profits.

(2) *Guide to breeding*.—Milk records are a guide to breeding and the selection of suitable animals for mating is rendered easy. It enables the elimination of unprofitable animals from the herd. Animals which give large quantities of milk for short periods and then fall off in yield give an erroneous impression that they are economic animals. Steady milkers maintaining a moderate flow of milk right through the lactation are not so impressive, but they are more economical. This has been proved by milk records repeatedly. Milk records show that people who take credit for being able to spot out good milkers are not infallible and that their appraisal are often incorrect. Milk records have enabled unprofitable cows being diverted to the production of beef in other countries and when the poor animals are systematically eliminated from breeding and begetting

poor stock, the average production of milk is raised in a few generations. All dairy countries recognise that milk records provide this invaluable guidance to the breeder.

(3) *Realising proper prices.*—Milk records enable cows being sold at proper prices with the backing of such records. The performance of the cows and their immediate parents are taken into consideration by purchasers and people are willing to pay more for animals whose performances are known, as it lessens the element of risk. When cows without any milk records are purchased, their capacity for production has to be judged by the configuration and external characters that indicate their capacity for milk production and these have to be proved at the purchaser's risk.

(4) *Keeping in touch with cows.*—Milk and feed records keep the dairyman in touch with the individual animals. Fall in milk yield of individual cows is noted then and there by the owner, and ill-health, improper management, etc., are readily noted in the early stages. It enables suitable remedial action being taken in time.

(5) *Selection of bulls.*—Milk recording enables the breeders to select suitable bulls, whose dams are known to be good milkers. The selection of proper sires for the herds has contributed to the improvement of milk yields of cows in other countries to a great extent. The use of bulls and heifers born of good milking animals and capable of transmitting the milk characters to their progeny is a certain method of increasing the milk yields of cows.

Breed associations.—These associations have been formed for the registration of certain breeds of animals. Most dairy countries have breed associations for their important breeds. When a breed association is formed, it takes up the work of registering animals that conform to the characters of the breed concerned. The working committee of the association decide whether animals offered for registration have the breed characters and are pure specimens of the breed. The offspring of registered parents are eligible for registration, without any other qualification whatsoever.

Certain associations close registration of new animals, after some years. Admissions are confined to the progeny of registered parents.

The registered animals are given serial numbers and the numbers are marked on the animals in an indelible manner. Tattooing the number in the ears is a common method, but is not suitable for animals which have dark skins inside the ears. Where the tatoo marks are not visible, numbers are branded on the skin of the animals with red-hot irons and this may be done on the hind legs, as low down as possible so that the value of the hide may not be impaired.

When animals are registered and given a number, a page is opened for each animal in the books of the association, in which are noted particulars regarding ancestry, the date of birth of the animal, the colour markings, the changes in colour with growth, marks on the animal which facilitate identification, and the performance of the animal. The performance of the animal consists of milk yields in cows and weights at different ages in the animals of the beef breeds. In the case of bulls, the performances of the ancestors, as well as those of their daughters, are entered. These furnish the history of the animals registered with the association and the book giving the history of the animals is called the 'Herd Register'. The herd register gives the genealogy of the animal or its pedigree. The breeders of the West pay high prices for animals with good pedigree, that is, animals which have descended from ancestors of merit.

Reputed breed associations periodically print copies of their herd books for sale. The breed associations also serve as milk recording societies, as far as their registered animals are concerned.

Milk recording in India.—Milk recording is not done in India, excepting in Government farms and some organised dairies. The animals maintained in these places are heavy milkers. The records of these farms and dairies are of value to their owners only and are at best an indication of the potentialities of the best animals in the country. These

are not officially tested records, as in the Western countries. Test recording of milk of the animals kept under village conditions has been done in some studies conducted by the Indian Council of Agricultural Research, New Delhi, and the record has been published by them. The studies were confined to certain selected dairying areas and do not therefore give a cross-sectional view of the whole country.

The yields of milk recorded in India are generally exclusive of what is consumed by the calf, before and after the the milk is drawn by hand. The milk allowed to the calf may vary with the individual milkmen. It can influence the fat test of the milk markedly. If the calf is allowed more of the fore milk, milk with low fat will be consumed by it and a high fat test for the rest of the milk will be the result. The fat test will also be high, if the cow is milked almost completely and very little milk is allowed to the calf after milking. The milk records in India are thus vitiated by allowing the calf to suck milk before and after milking and to consume an unknown quantity of milk. Enquiries made in villages in certain dairying areas by the Indian Council of Agricultural Research indicate that the quantity of milk allowed to the calves may average about 274 lb. for cows and 369 lb. for buffaloes per lactation.

Average milk production in India.—It has been estimated that the average lactation yield of hand-drawn milk is 413 lb. for cows and 1,101 lb. for buffaloes[20] in the Indian Union. To this may be added the milk allowed to calves and the total average production estimated at 687 lb. per cow and 1,470 lb. per buffalo per lactation.

CHAPTER XXI

THE MARKETING OF MILK

Production and handling milk.—It has been shown that milk is produced in India, under conditions which are extremely unsatisfactory. The marketing of milk is also equally unsatisfactory. Milk is taken for distribution in open vessels, with wisps of dry straw, green leaves, etc., to prevent agitation of milk during transport. These increase the bacteria in milk and affect its keeping life perceptibly. Notwithstanding all these, milk has not been contributing to the spread of epidemic and other diseases widely here, as it is universally boiled in the household before consumption, a process that makes up for all the sins of commission and omission, at the several stages of producing, handling and transporting milk.

Intensity of milk production.—Most of the milk is produced in small holdings, with generally 2 to 3 cows in each, both in rural and urban areas in India. Larger number of animals are maintained in a few holdings only. The average daily production of milk in a village is about 200 lb. and in individual holdings 4 to 8 lb. The collection of such small quantities of milk, their bulking and their distribution twice a day in small quantities to different consumers, before the milk loses its keeping quality form a difficult problem.

The collection of milk in the Western dairy countries, which have developed satisfactory methods of distribution, is rendered easier by the intensity of milk production and the favourable temperate climate. Individual producers have on the average 9 cows in Denmark, 12 in U.S.A. and 24 in Great Britain and the average milk yield is 15 to 20 lb. per animal per day. The average daily production of milk is about 320 lb. in a holding in Great Britain and this is collected, bulked and distributed once a day.

Disposal of milk.—A large part of the milk produced in the Indian villages is consumed by the producers and the

surplus is converted to ghee. The urban consumption of milk is about a fifth of the total production in the country. The urban demand is met by the small urban producers to an extent of 60 to 70 per cent. and the rest by collections from the villages round about, at distances of 5 to 15 miles.

Transport of milk to towns.—The milk is transported to towns from nearby villages in head loads. Transport of milk in cans on bicycles has developed in recent years. The quantity of milk carried by a bicycle ranges from 40 to 150 lb. Motor lorries are used to a limited extent by the larger co-operative milk supply societies. Small quantities of milk are also taken to Madras by train.

Quality of milk.—The quality of milk offered for sale is very deplorable. Its bacterial content is very high, and this reduces its storage life and keeping quality. The milk develops acidity easily and gets curdled, when kept over. It is also adulterated with water and very liberally sometimes. Where cream separators are in use, skim-milk is often used as an adulterant. The watery appearance of the diluted milk is sometimes attempted to be masked by the addition of flour.

The price of milk.—The following are the retail prices of milk in some selected countries, during 1938 and 1947[20] according to the bulletin on *Dairy Products*, February 1950, issued by the Food and Agricultural Organisation, converted to Indian coinage.

Country	Price in annas per lb. (1938)	Price in annas per lb. (1947)	1947 price as percentage of the 1938 price
United Kingdom ..	2·5	3·2	129
Ireland	2·0	2·4	120
Sweden	1·25	1·7	134
Denmark	1·55	2·35	131
U.S.A.	2·9	3·45	119
Canada	1·95	2·65	137
New Zealand ..	1·8	2·05	110
Indian Union—			
(*a*) Raw milk ..	1·2	5·0	414
(*b*) Pasteurised milk	2·5	6·0	240

The price of raw milk was the lowest in India during 1938 and the highest in the world during 1947. There has been a rise in prices of milk during this period in all the countries of the world and the average rise is about 25·7 per cent. as against a phenomenal rise of 314 per cent. in India. The retail price of milk is high in other countries, when compared to the price paid to the producers, chiefly because of the high cost of pasteurising, bottling and distribution. The cost of such services was 40 per cent. of the retail prices in England during 1939. In India, milk is collected from the villages and retailed in towns, without pasteurisation or any processing. The part of the price paid by the consumer and appropriated by the distributing agency is about 37 per cent. or nearly as great a fraction as the cost of pasteurising, processing and distribution in England.

It has been estimated that with the price of fluid milk as 100, the relative returns obtained by the sale of ghee is only 58. Thus if the milk that is used for the production of ghee in the villages is transported in a suitable manner as fluid milk to consuming centres, the producers will be enabled to get better returns for the milk produced by them. It is only when milk is consumed as fluid milk that the value of milk and its nutrition are fully utilised. When milk is converted to other products, certain portions of milk are eliminated and this should preferably be avoided in a country, which is not producing enough milk to feed the people properly. The consumption of fluid milk is limited at present and requires to be encouraged, by providing facilities for quick transport of milk from producing to consuming centres.

The transport of fluid milk over long distances is not possible, under the prevailing temperature, which promotes the rapid multiplication of bacteria in milk and affect its keeping life. Refrigeration of milk increases the cost abnormally and is beyond the capacity of the consumers and the effective demand for such costly milk may be very low.

Transducers have not been tried in this country. Their trial for transport of milk is indicated and their use may

assist the development of the flow of milk from the rural to the urban areas.

Recent developments in urban milk distribution.—With the encouragement given by Government, co-operative societies have made considerable headway in the distribution of milk in urban areas, during recent years. There were on 30th June 1950, 36 milk supply unions and 535 milk supply societies in Madras State. The supply societies had 49,952 members with a paid-up share capital of Rs. 7·27 lakhs. The value of milk and milk products sold during 1949–50 by the co-operative societies and unions was 83·68 and 66·19 lakhs of rupees respectively.

A co-operative society has a village or a number of villages close to one another, as the unit of operation. These societies are affiliated to unions situated in towns. The cows and buffaloes are assembled in the premises of the societies and milking is done under the supervision, provided by the societies. The milk drawn is measured and taken over by the societies. After the completion of milking, the milk is bulked in suitable milk cans and delivered to the lorry of the union, which collects the milk cans from the several feeder societies. The union in the town receives the milk and arranges to distribute it through milk depots located at suitable points in the town and also through cycle vendors at the customer's house. When milk is delivered through cycle vendors, a charge of Rs. 2 a month is collected from each customer for this service, by some of the unions, like the Madras Milk Supply Union. The milk sold through cycle vendors is through sealed milk cans, provided with a tap at the bottom. The milk is drawn through the tap in half and one pound measures and delivered to the customers. The supply of milk from sealed cans has one serious disadvantage. The fat in milk gets concentrated at the top, if the distribution of milk is not done within a short time of filling the can. People who draw their supplies first get milk with a low fat content and the last few customers get milk rich in fat. The provision of a metal plunger, with a handle

projecting through the lid, for agitating the milk at the time of delivering milk would mix it thoroughly and would make the distribution fair and even.

A part of the profits of the societies is earmarked for reserve fund and common good fund. A portion is paid as dividend to the shareholders and the balance is paid as bonus on milk delivered to the Union or the society.

Some important milk supply unions in Madras.—The Madras Milk Supply Union is the biggest organisation of the kind in India. It has a pasteurising plant and distributes the morning drawn milk in the evening and the evening drawn milk next morning after pasteurisation. The other important Unions are those at Coimbatore, Kozhikode, Tiruchirapalli and Ootacamund. The quantities of milk distributed by them during the year 1949–50 were as follows according to the report on the working of the Co-operative Societies in the Madras State for the year ending 30th June 1950:

Name of the Union	Quantity of milk handled in lakhs of pounds	Purchase price of milk in lakhs of rupees
Madras ..	83·93	21·56
Coimbatore ..	25·48	6·45
Ootacamund ..	24·25	5·84
Kozhikode ..	..	3·35
Tiruchirapalli ..	..	3·15

Co-operative Societies have opened the way for the flow of milk from the rural areas of production to urban centres, where there is effective demand. Following the lead, certain individuals collect the milk from villages and sell it in towns. The transport of milk from the villages to towns is largely done with bicycles. The milk cans used for transport are made of galvanised iron sheets, which have been shown to be extremely unsuitable for handling milk. The cans are not properly cleaned and sterilised, with the result that the milk offered for sale has a pronounced sour smell,

combined with metallic taint, patented features of this type of distribution. The milk acids and zinc dissolved therein are thus common ingredients of milk distributed in this manner. Time will show how the ingestion of zinc in small doses regularly is going to affect the human health and system. The distributors, inclusive of some of the co-operative societies, appear to be unmindful of this. The cost of galvanised cans is low and this alone appears to have been the consideration that has counted. There is no doubt that more harm than good can result by the adoption of improper methods of pooling and distribution of milk. There is great need for inculcating vigilance, care and elementary hygienic knowledge and consciousness in people who handle milk and who direct distributing agencies. The milk offered directly by individual producers to consumers is by contrast free of these defects, though as has been pointed already, it has other defects.

GLOSSARY

Vernacular or Common Name	Botanical Name
Ragi or *ragulu* or *keppai*	*Eleusine coracana*
Tenai or *korra*	*Setaria italica*
Samai or *samulu*	*Panicum miliare*
Panivaragu or *varigalu*	*P. miliaceum*
Kudiraivalli or *oodalu*	*Echinochloa frumentacea*
Varagu or *arika*	*Paspalum scrobiculatum*
Kolakattai grass	*Cenchrus ciliaris*
Chengalli gaddi	*Iseilema laxum*
Guinea grass	*Panicum maximum*
Napier grass	*Pennisetum purpureum*
Water grass or buffalo grass	*Brachiaria mutica*
Bengalgram or gram	*Cicer arietinum*
Redgram	*Cajanus indicus*
Horsegram	*Dolichos biflorus*
Dewgram	*Phaseolus aconitifolius*
Pillipesara	*P. trilobus*
Water hyacinth	*Eichhornia crassipes*
White babul	*Acacia leucophlœa*
Babul	*A. arabica*
Mullu kiluvai	*Commiphora berryi*

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